



The Case for Alternative Sources of Liquid fuels & Petro-chemicals and the Development of Regional Hydrocarbons Infrastructure in the SADC, with a Focus on Malawi

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Abstract

Energy security, particularly liquid fuels, is a vital economic goal for both developed and developing nations. As a region, SADC has large coal, oil and gas reserves, and land for potential crop production for biofuels, yet access to liquid fuels is still a major constraint to economic and social development. Some coal is utilised in the region for petrochemical industries, power generation, and for heating. Crude oil reserves are largely exported due to the lack of refineries and pipelines in the region. Whilst biofuels production is in its infancy. This paper explores the challenges and opportunities the SADC region faces in developing refining capacity and in investing in new CTL/GTL facilities as well as liquid fuels from renewable energy resources. A primary focus will be on Malawi and her neighbouring states, as a case study.

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Abbreviations

AZOP.....	Angola - Zambia Oil Pipeline
BBL/D.....	Barrels Per Day
CEAR.....	Central East African Railways
CTL/GTL	Coal to Liquid/Gas to Liquid Technologies
EAC.....	East African Community
FDI.....	Foreign Direct Investment
F-T.....	Fischer-Tropsch Process
ISI.....	Import Substitution Industrialisation
LDCs.....	Less Developed Countries
MNCs.....	Multinational Companies
NGOs/NPOs.....	Non-Governmental Organisations
PPPs.....	Private Public sector Partnerships
RMCs.....	Regional Member Countries (SADC)
SADC.....	Southern African Development Community
SAPs.....	Structural Adjustment Programs
SOCs.....	State Oil Companies

1. Introduction

Energy security is a vital economic goal for both developed and developing nations. Technological advancements have allowed for new methods of production such as the conversion of coal and gas to liquid fuels and biofuels to ameliorate crude oil price volatility, global warming concerns (in the case of biofuels) and crude oil scarcity. Despite SADC's abundance in crude oil reserves it is logistically more affordable to procure liquid fuels from gulf countries (India) due to the lack of intra-regional infrastructure in SADC (SADC, 2012; Golinska & Kawa, 2015).

The huge surges in oil prices from 2008-2010 that stabilised at about \$100 in 2014 fuelled oil scarcity and peak oil debates. High oil prices were detrimental to economic growth of non-oil producing countries but fuelled the investment of alternative non-conventional oil projects for petroleum products that were previously not viable due to low crude oil prices (Golinska & Kawa, 2015). The falling oil price of the period (2015-16) has had detrimental impacts to these investments and some companies have gone bankrupt as a result, as these projects are bound by a price floor of about \$65-90 a barrel (Brammer & Reuter, 2009). The volatility of the crude oil prices have therefore influenced nations both developing and developed to develop strategic infrastructure and national strategies to secure energy security in terms of liquid fuels and technologies for producing liquid fuels and biofuels. In addition the pressures of climate change have driven the development of biofuels.

Malawi post-independence, as most newly independent African states inherited a legacy of low education levels and limited infrastructure. There was a general consensus amongst the liberation leaders that they would have to adopt big-push economic models to build infrastructure and to increase the literacy bases (Mkandawire, 2010). This view was accompanied by large investments in roads, rail, education, health and energy infrastructure to aid critical sectors of these newly democratic states. However, many of these investments did not escape the industrial demise that the Washington consensus brought about from the 1980s (Fine, 2006; Mkandawire, 2010; Amsden, 2007). The remnants of this are not hard to see. The closure of the TIPEIR Petroleum Refinery in Tanzania in 1991, the neglecting of the Malawian storage

facilities for petroleum fuels, the running down of rail networks and institutions of higher learning and the privatisation of state utilities are examples of the consequences of the adoption of pro-neoliberal policies (Fine, 2006; Kalinga, 2011). Despite the fact that the aforementioned state facilities and infrastructure once functioned, it seems impossible to the younger generation that lived through the Bakili Muluzi regime from (1994-2004). However, these remnants provide a critical base of skills and infrastructural capacity from which industrial capacity could be built in order to achieve regional energy sector goals.

This paper aims to explore and analyse the viability of the alternative sources of liquid fuels that are available to Malawi and other developing nations in the SADC region. It aims to analyse and outline the socio-economic opportunities and challenges that RMCs have in the upgrading of current infrastructure for transporting and refining crude oil; in developing CTL/GTL technologies and in developing the biofuels sector.

Secondary data including reports, feasibility studies, academic literature, maps, raw data and graphs as well as insights from interviews were used and analysed for research purposes. Firstly, an overview of the current energy sources is attempted including the development of the historical and current infrastructure for transporting/storing and refining liquid fuels, CTL/GTL technologies, biofuels and potential oil in Lake Malawi, in order to introduce some of the historical, and socio-economic challenges surrounding these resources.

The main of the paper covers three areas, namely, the development of historical and current infrastructure for transporting and refining crude oil, CTL/GTL technologies and the development of the biofuel industry. Part of the SADC region will be used as a case study with the Republic of Malawi as the primary focus to aid a discussion on the socio-economic impacts and debates, political lobby groups and the case for economic integration. Policy recommendations and concluding thoughts are then given.

2. The current world market for oil: Production versus consumption in SADC

Oil and gas are hydrocarbon fossil fuels that occur as accumulations trapped in geological structures in permeable reservoir rocks beneath the earth's surface. Oil is the

second most abundant liquid on earth after water (Hart, 2012). This relative abundance, coupled with the falling oil prices of 2015-16, have largely nullified peak oil debates, as it is now apparent that there are considerable reserves and resources of crude (Hart, 2012) and unconventional crude (tar sands and oil shales). There is a growing demand for petroleum because as nations develop, their liquid fuels energy needs increase. This increase is attributable to transport sectors, mining activities and other industrial activities. Therefore, as nations industrialise a significant national goal is to secure the expertise and the technological capabilities that are utilised in the production of petroleum products (Khan, 2009; Tonurist, 2015).

This explains the formation of national oil companies in various countries. The Chinese national oil company, the Russian oil company and the Venezuelan oil company are examples of state oil companies (SOCs) that have been developed to achieve national goals such as energy security. State owned oil companies have been successful even under competition from private companies (Mfosi, 2011). Countries that do not have an SOC should consider developing this capacity as it is critical for nations to take control of mineral resources in order to build the necessary infrastructure and institutional structures that are needed to deal with liquid fuels energy insecurity.

The formation of SOCsoften involves the nationalisation of oil facilities. There is however an underlying resistance and distaste for pro-nationalisation theorists in orthodox economics that is endorsed by the economic think tanks such as the World Bank, IMF and American and European policy makers (Mfosi, 2011; Fine, 2006). Bilateral trade and investment agreements between SADC countries and the European Union therefore unsurprisingly prohibit the nationalisation of private companies. Experiences from the East Asian tigers suggest that departing from the western policy paradigm in some key sectors and policy spaces does produce favourable economic outcomes if implemented in the structure and environment of a developmental state (Amsden, 2007; Chang, 2003; Takala, 2014).

Sub-Saharan Africa's abundance in natural resources has generally been the curse of the region (Mehlum, Moene & Torvik, 2006). Discoveries in natural resources have been

characterised by long periods of colonisation, dehumanisation and conflict not too different from the experience of the oil discoveries in the Middle East. Both are experiences that have been well documented.

Figure1 illustrates the distribution of world oil production. It is particularly concentrated in the USA, Russia and the Middle East; followed by the Far East and the North and South Americas. Africa has oil production in the north in Algeria and Libya, in the west in Nigeria, in the southern central region in Angola and in the east in North and South Sudan (BGR, n.d.). Hardly any of these countries has not had conflict therefore, resource curse theorists have substantial empirical evidence to back up their claims (Mehlum et al, 2006). Despite this reality there is growing demand for liquid fuels in sub-Saharan Africa, a region that has high energy insecurity issues.

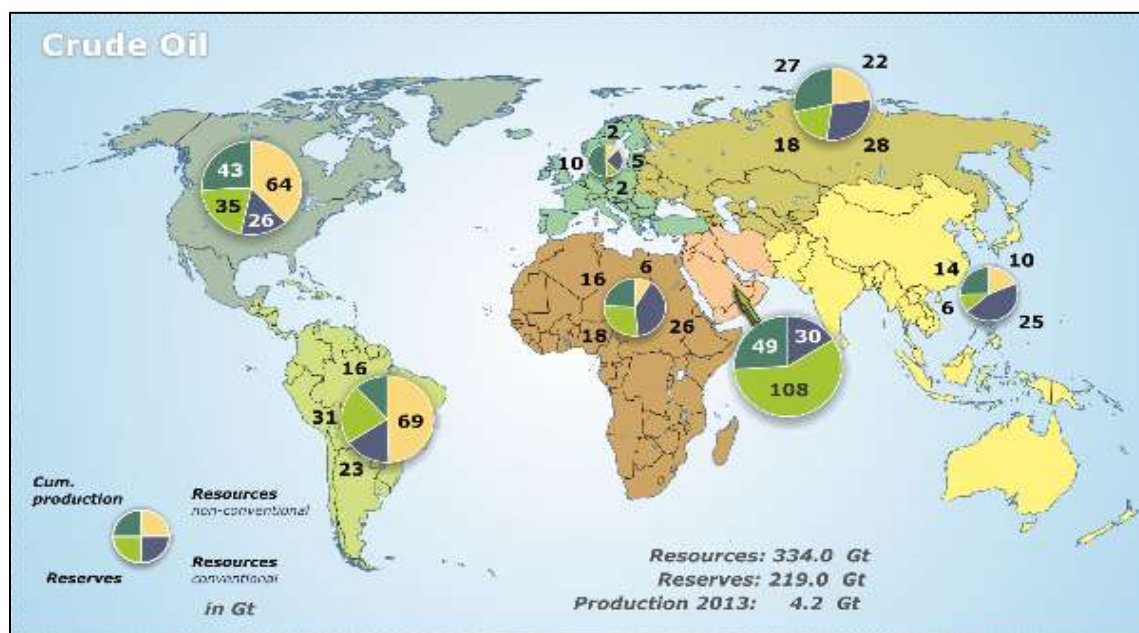


FIGURE1: REGIONAL DISTRIBUTION OF CRUDE OIL PRODUCTION, RESERVES AND RESOURCES, 2013

Source: BGR, (n.d.)

SADC is a region that should not have energy security issues, particularly liquid fuels. It is a region that has high unexploited renewable liquid fuels energy resources, conventional resources such as oil (SADC, 2009) and unconventional resources such as coal, gas/shale gas and coal bed methane (CBM). However, most of these oil and

gas resources are largely unavailable to the region due to foreign obligations and limited infrastructure for producing and transporting liquid fuels in the region (using both conventional and unconventional production methods) (Yates, 2009). Industrial development and expansion of the middle class in the region are the primary drivers of the increased demand for petroleum fuels such as diesel, petrol/gasoline, jet fuels and heating fuels.

From 1980 to 2013, Angola has significantly increased its oil production from less than 200 000 barrels to approximately 2000 000 barrels of oil a day (Soque, 2013). South Africa, due to the economic gains of SASOL, has increased its production of synfuels from 0 in 1950 to 166 000 barrels a day in 2012 (Radebe, 2012). South Africa's increased production is due to investments into CTL/GTL technologies. CTL/GTL technologies were utilised in Germany during world WWII (Sparks, n.d.).

The success of SASOL is largely attributed to government support in the form of subsidies, that the entity received under the apartheid government from 1950 onwards, and due to the sanctions that the country was subjected to during that regime. The sanctions served as an indirect policy framework that protected and developed the petro-chemical industry in South Africa. Disruptions in trade relations with Iran as a result of the revolution in Iran in 1979 impacted the supply of crude oil into South Africa. This required an emergency expansion of SASOL. The government lacked the resources to invest and therefore raised the funds on the stock exchange, effectively privatising the SASOL SOE (Ebrahim, 2015; Sparks, n.d.).

Angola's oil production is due to its endowment. The Cabinda off-shore reserves were discovered by US MNCs in the 1950s. Cabinda Gulf Oil (Cabgoc now a part of Chevron) was the first company to be given concession rights in the Cabinda region in 1957. Numerous other foreign companies and FDI flows have entered the country's oil sector since (Redvers, 2013). Although FDI flows have brought about significant growth of the oil industry, all the crude oil is exported out of SADC due to the already mentioned limitations of the lack of infrastructure as well as foreign obligations in terms of honouring contracts to trading partners with ex SADC countries (Redvers, 2013;

Kiala&Ngwenya, 2011).The implication of this reality for non-oil producing RMCs is that oil has to be procured from overseas countries that have large refining capacities of between 200k to 300k bbl/d. This effectively reduces the gains of downstream forward opportunities, particularly economic linkages into the petro-chemical industry that the region could exploit, due to crude oil refining activities(EIA, 2005; Redvers, 2013).Table 1 shows the SADC oil production, resources and estimated recoverable resources.

RMC	Production	% SADC	Cumulative Production	Reserves (Mt)	Resources (Mt)	% SADC	EUR* (Mt)	% SADC	Remaining Potential
Angola	84.7	98%	1475	1723	52	3%	8398	69%	6923
Congo, DRC	1.2	1%	45	24	145	8%	214	2%	169
Madagascar	0.0	0%	–	–	90	5%	90	1%	90
Mozambique	0.0	0%	–	2	2	0%	2002	16%	2002
Namibia	0.0	0%	–	–	150	9%	150	1%	150
Seychelles	0.0	0%	–	–	470	27%	470	4%	470
South Africa	0.2	0%	16	2	400	23%	418	3%	402
Tanzania	0.0	0%	–	–	400	23%	400	3%	400
Zimbabwe	0.0	0%	–	–	10	1%	10	0%	10
Total	86.1	100%	1536	1751	1719	100%	12152	100%	10616
*EUR: estimated ultimate recovery. Source BGR 2014									

TABLE 1: SADC OIL PRODUCTION, RESOURCES AND ESTIMATED ULTIMATE RECOVERY, 2013 (Mt)

Source: BGR, (2010)

The estimated ultimate recovery measures the likelihood of finding oil reserves given the geographic formulation of the land and sea beds. The EUR estimates take into account both the proven and unproven oil discoveries. Angola and Mozambique have the highest EUR estimates. While it is well known that Angola has large oil resources, Mozambique has very little oil production but a considerable amount of natural gas resources. The discovery of natural gas in Mozambique increases the likelihood of future discoveries of oil hence the high EUR ratings in table 1. There have been some oil discoveries in Ruvuma province and Sasol has been a key developer of oil exploration and production in the region. Although the discovery and production rates of

oil are relatively low at this point in time there is significant potential for eastern SADC if Mozambican oil reserves are discovered and the required infrastructure to extract and distil them is constructed under the right policy umbrella(Andruleit et al, 2014).

2.1 Overview: Historical and existing liquid fuels infrastructure

The post-independence Malawian government like other newly independent African states invested heavily in infrastructure (Mkandawire, 2010). The petroleum infrastructure that the Malawian government invested in comprised of the following:

- Petroleum storage tanks in Mbeya in south-western Tanzania north of the Malawian border;
- The MV Ufulu which is a water vessel designed to carry petroleum fuels and in the Chipoka; and
- Chilumba ports in the north and southern districts of Malawi (Kalinga, 2011).

Zambia and Tanzania both invested in rail and pipeline infrastructure. The TANZAM pipeline is 1700km long. It connects the Dar es Salaam port to the TAPEIR refinery (Tanzania) as well as to the Indeni refinery in Zambia. The Tazara railway line was completed in 1975 and stretched from the Dar es Salaam port in Tanzania through the south-western town of Mbeya (232km north of the Chilumba port in Malawi) to the central province of Zambia which is known for copper production (Kalinga, 2011).

In 1987 the governments of Zambia, Malawi and Tanzania signed an agreement that opened up the north corridor for Malawi. This meant cargo (both wet and dry) could be transported by rail and the TANZAM pipeline to the south-western Tanzanian town of Mbeya and then transported by road to the Chilumba port in northern Malawi. Cargo could then be loaded onto the water vessels: the MV Illala, MV Mtendere and the MV Ufulu that would transport wet and dry cargo to the central and southern districts of Malawi (Kalinga, 2011). This was followed by the rehabilitation of the southern corridor that was affected by Renamo insurgents during the civil war in Mozambique. The southern rail-corridor connects the port of Beira (Mozambique) to Blantyre (Malawi). It

then connects to Salima (Chipoka port) and Lilongwe and ends at the Zambian border in Chipata (Jica, n.d.; Kalinga 2011).

The civil war and political instability in Mozambique, which was partially fuelled by Malawi, influenced the Malawian government to look at the southern, central and northern corridors as alternative routes that could be utilised to transport petroleum and diesel fuel into Malawi. The Shire Zambezi waterway is another infrastructure project that has the potential to provide an alternative corridor for the transportation of liquid fuels (Lalbahadur, 2013). It is a historic route that Europeans and early missionaries (Dr David Livingstone) are said to have used when they explored Southern Africa (Kalinga, 2011).

This river transport route flows from the Indian Ocean at the Mozambican old port of Chinde, into Zambezi River and then into the Shire River to Malawi's southern districts of Nsanje and Chikwawa (AFDB, 2014; Lalbahadur, 2013). Arguably the Shire Zambezi waterway project goes against political interests of some lobby groups in both Malawi and Mozambique that are heavily invested in road transport (Ncube, Roberts & Vilakazi, 2014; Lall, Wang & Munthali, 2009).

Competition from trucking and the mismanagement of the lake services of Malawi had a detrimental impact on infrastructure maintenance and the development of water and rail transport in Malawi (Kalinga, 2011). The former SOE Lake services was responsible for the development and governance of water and rail transport in the country. Mismanagement and influence of SAPs have led to the privatisation and unbundling of the entity (Mathur, 2000). The water transport operations of Lake Services are now under private control of the Brazilian company, MotaEngil, which is constructing the Nacala Rail corridor (MotaEngil, 2013).

The rail operations are under the control of The Central East African Railway Company (CEAR). Investments in new ships and locomotives for the transportation of people and cargo have taken place since this change of ownership. This policy stance could improve efficiency and channel investment into the rail and water transport

infrastructure that is needed to develop the aforementioned entities into economically viable entities that could compete with road transport in Malawi. The success of this PPP could have a positive impact on the pricing of the transportation of liquid fuels and therefore the pump price of liquid fuels.

2.2 Overview: CTL/GTL Technologies

The discovery of large coal and gas reserves in Mozambique has attracted large flows of FDI. The quantity of the coal reserves is uncertain but BGR estimates that the Moatize region has reserves that amount to 23 (GT) (Bayura&Kessels, 2013). The Moatize coal production is mainly for export, however a portion of it could potentially be utilised in electricity generation, steel manufacturing industries and in liquid fuel production for the SADC region. One of the mining giants in the region is VALE and like SASOL, Vale received considerable State support from the Brazilian government and its success can largely be attributed to state support (Musacchio&Lazzarini, 2014). Part of Vale's investment has been channelled to the development of the Nacala rail corridor. In 2010 Vale acquired 51% of the Development Company of the Nacala Corridor (SDCN), which, in turn, holds most shares in The Central East African Railways Company (CEAR) (AFDB, 2015). The development of this transport infrastructure has provided essential opportunities and an alternative rail corridor to consider in assessing the viability of CTL technologies in the Moatize region and potentially Malawi (Musacchio&Lazzarini, 2014).

2.3 Overview: Lake Malawi Potential Oil Reserves

The possibility of oil reserves in Lake Malawi have been a long debated issue. Some scholars argue that, if reserves are discovered, there is the on-going risk of a resource curse that has plagued most oil rich nations: Dutch disease, civil wars, oil spills and environmental concerns (Mehlum et al, 2006). It is not a far-fetched assertion to assume that drilling oil in Lake Malawi would result in the same fate that African exports suffer when it comes to value chains; export of crude oil and import of refined petroleum products: petrol and diesel.

The Malawian government has awarded exploration licences to SACOIL, Rakgas, Pacific Oil and Surestream Petroleum (Etter-Phoya, 2015). There was a ban on exploration in Lake Malawi that was imposed by the government due to a public outcry and fears of irregularities in the process of awarding licenses. This ban has recently been lifted allowing proceedings to continue. Figure 2 shows the licensing block distribution.

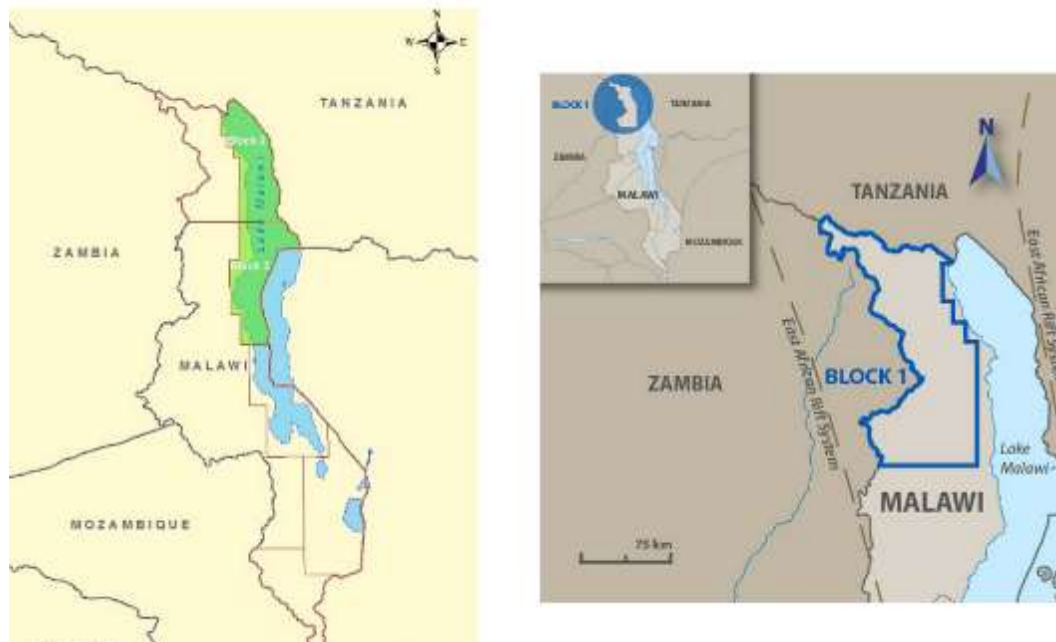


FIGURE 2: MAP OF THE DISTRIBUTION OF LICENSING BLOCKS

Source: www.energy-pedia.com, (n.d.)

It should be noted that Malawi has about seven prominent tribes: Tumbuka, Tonga, Chewa, Ngoni, Lomwe, Nsena, Yao (Kalinga, 2011). Each of these tribes has their own distinct culture and language and all take ownership of Lake Malawi and its resources. This diversity in cultures could be a potential recipe for civil war in the country. Cultural differences in tradition and religion amongst the populations are areas that are targeted by interest groups that seek to destabilise regions (Rodney, 1973).

Environmental lobby groups and theorists also have cause for concern as there have been numerous environmental violations by multinational companies in the past (Nixon, 2008). The recent oil spills by British Petroleum off the Gulf of Mexico and the pollution

in the Nigerian delta are a few examples of this occurrence. It is important to give consideration to these realities of environmental abuses and potential civil wars occurring as policy makers should consider the development and capacity of their institutions in assessing whether these institutions are strong enough to bring multinational companies like Shell to account and to deal with extremist groups that may destabilise the region (Nixon, 2008).

Lake Malawi has a depth of 700 meters. Drilling oil in Lake Malawi at this depth would be considered deep-water drilling and is therefore one of the riskiest and most expensive methods of drilling oil. It therefore poses environmental risks and financial implications. The fishing and tourism industry are significant sectors of the Malawian economy. Disruptions in these sectors could have massive socio-economic issues for lake communities therefore there is serious cause for concern (Deep Sea World, n.d; Golinska & Kawa, 2015; Nixon, 2008). Advancements in technology for deep oil drilling have been developed and made safer overtime. However, as oil spills are sometimes caused by human negligence and unforeseen circumstances the risks cannot be guaranteed. Environmental institutions in Malawi are also relatively weak, making their ability to monitor environmental abuses questionable (Mkondiwa, 2010).

3. Refinery capacity in SADC

The SADC region has a shortage of refineries. Most refineries are concentrated in South Africa. There is additional refining capacity in Luanda, Angola, Ndola, Zambia and the Congo. Previously Tanzania had refining capacity; however, it was closed down due to the structural adjustment programs in the early 1990s and early 2000s (Kalinga, 2011; Redvers, 2013). There is therefore a total combined refining capacity of about 550 k bbl/d. SADC currently consumes about 923k bbl/d (EIA, 2015). The deficit is met by offshore oil suppliers: from refineries in Singapore, India and other countries with larger refining capacity. Figure 3 shows the refining capacity of countries in the region.

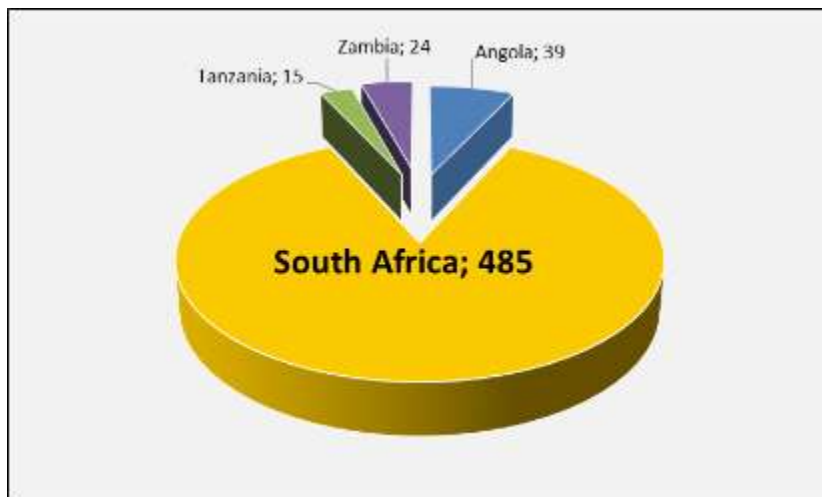


FIGURE 3: SADC CRUDE OIL DISTILLATION CAPACITY (KBBL/D).

Source: US EIA,(2015) (www.eia.gov), Note: Although the US EIA reports a 15kbbbl/d capacity in Tanzania, this has reportedly shut down. Also Oil, Gas Africa reports a Chevron Cabinda refinery of 16kbbbl/d. Source: US EIA 2015 (www.eia.gov)

South Africa has a refining capacity of 485k bbl/d. Angola has a capacity of 39k bbl/d and Zambia has a capacity of about 24k bbl/d (EIA, 2015).Figure 4 shows the estimated refined petroleum consumption of SADC.

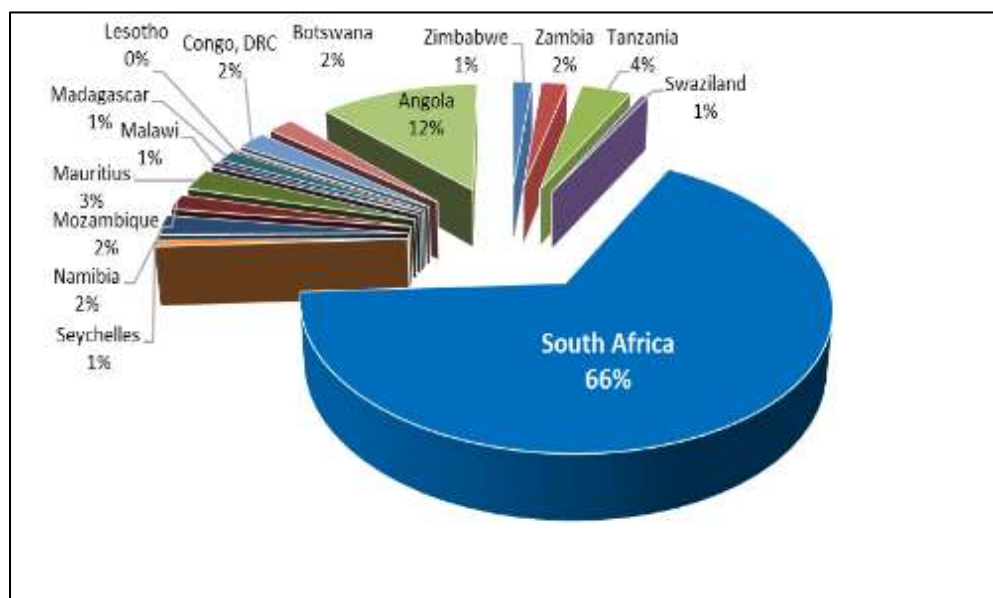


FIGURE 4: SADC ESTIMATED LIQUID FUELS CONSUMPTION 2013 (923KBBL/D)

Source: CIA,(2015)

Total consumption of petroleum products in SADC is 923k bbl/d. South Africa contributes 66% of consumption. Angola follows with about 12% and the other RMCs collectively contribute 22%(CIA, 2015).Therefore there is a current shortfall in refining capacity of 400k bbl/d. After the completion of both phases of the Sonaref Lobito refinery, which will have a capacity of 200k bbl/d, Angola will be in surplus and will reduce the current shortfall of 400k bbl/d to about 200k bbl/d in SADC. The shortfall will primarily be in South Africa.

3.1 Refining Capacity in Angola

Angola produces 2 million barrels of crude oil a day. The country has a refining capacity of 39k bbl/d of crude and a consumption rate of about 111k bbl/d. This effectively means there is a shortage of about 72k bbl/d (EIA, 2015). The limited diversification and concentration in oil production of the Angolan economy leave the country vulnerable to oil price shocks(Redvers, 2013;Golinska& Kawa, 2015).The limited refining capacity also limits the quantity of petro-chemicals available that can feed into manufacturing, agriculture and other industries that Angolan policy makers could exploit.

The current reduction in oil prices has had significant implications for the Angolan economy. China has been a primary trading partner for Angola. In 2004 when Angola was seeking to rebuild war-torn infrastructure Western nations were reluctant to offer financial support. This coincided with changes in Chinese foreign policy that were seeking to partner up with African countries. This development led to the approval of a \$2 billion loan from China to Angola. It was to be paid back with crude oil rather than hard currency but was free from the conditions of western conditionality (Yates, 2009). A series of economic exchanges and oil backed loans for investments have since followed, however the falling oil price has had implications on the Angolan government's ability to service historical debt (Redvers, 2013; Yates, 2009).Figure 5 shows the oil price volatility from 2007 to 2015.

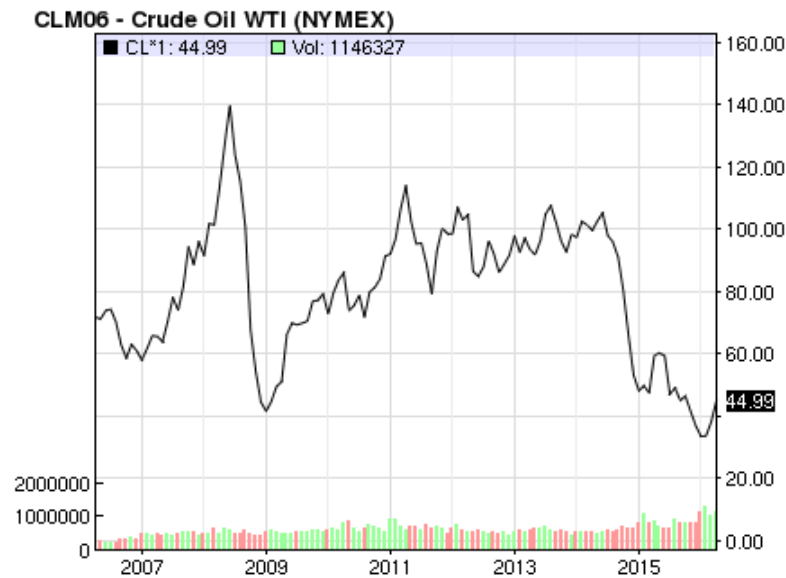


FIGURE 5: CRUDE OIL PRICE VOLATILITY (2007-15)

Source: NASDAQ (2016)

The above economic arrangements coupled with the few refineries in SADC mean that almost all crude that is extracted is exported. The main trading partners for Angola's oil are China, India and the United States of America. Figure 6 shows the distribution of Angola's trading partners. South Africa is the only RMC that is in the top ten of Angola's trading partners and accounts for only 4%.

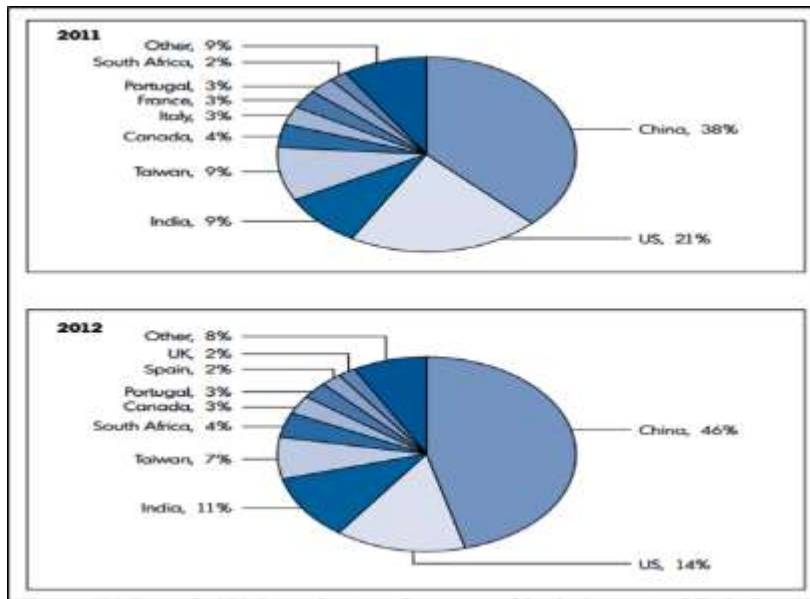


FIGURE 6: ANGOLA TRADING PARTNERS

Source: Redvers, (2013)

The SADC region is a readily available market, but the lack of a pipeline network, rail and refining capacity makes it an inaccessible one. It is therefore more economical for RMCs to import refined petroleum from ex- SADC sources. However, there are announcements of PPP projects that are being looked at to connect Angola to Zambia (Udoh, 2012; Mfula, 2012). One particular project is the AZOP pipeline that is designed to transport multiple finished products including petrol, low sulphur diesel, Jet fuel and Liquefied Petroleum Gas (LPG) to Zambia, and the Katanga Province in the DRC (Udoh, 2012; Mfula, 2012).

The above pipeline project is reported to commence after the completion of the Sonaref Lobito refinery that will have a total capacity of 200k bbl/d. This will put Angola in surplus of petroleum fuels. The surplus of refined petroleum in future could be exported to Zambia via the AZOP pipeline or via the rehabilitated Benguela railway line. In addition to the central SADC market, Angola could supply western SADC market (Namibia, DRC) via sea tankers (SADC, 2012).

3.2 Refinery Capacity in Zambia

Zambia has some oil refining capacity that is controlled and owned by the government of Zambia. The Indeni refinery has the capacity of 24k bbl/d. Zambia has no known reserves of oil and therefore has no production of crude oil (Rukuru, 2013). The TANZAM pipeline between Tanzania and Zambia was initially constructed 1968 to transport crude from the Dar es Salaam ports and TAPEIR refineries (Kalinga, 2011). It stretches 1,700 km and has a capacity to transport a million tons of crude a year (Cilliers & Mashele, 2006).

The Indeni refinery is not configured to fully process pure crude oil. It is a simple refinery and therefore it is not sophisticated enough to process pure crude as it cannot crack or break the heavier fuel oils into lighter petroleum products like petrol and diesel. Being a simple refinery, Indeni therefore processes a spiked or commingled feedstock. This feedstock is imported primarily from the Middle East and is transported to Indeni via the TANZAM pipeline (Zambian Energy Regulation Board, n.d.). The Indeni refinery does not have the capacity to amply serve Zambia's growing demand of liquid fuels. Therefore this motivates the development of the AZOP pipeline that could prospectively fill the deficit from the Sonaref Lobito Refinery. Figure 7 shows the TANZAM pipeline route.



FIGURE 7: TANZAM PIPELINE ROUTE

Source: Tanzania Zambia Railway Authority, (n.d)

3.3 Refining Capacity South Africa

South Africa has the highest demand for liquid fuels in the region. The country also has the most refining capacity. Shell, Total, Chevron, Engen and Sasol are companies that have controlling interests in South Africa's oil refining industry. Table 2 shows South Africa's ownership and crude throughput.

South African Refinery Ownership and Crude Throughput		
Crude Oil Refined at the following refineries:		
Name	Crude throughput	Ownership
Chevref	100,000 bpsd	Chevron South Africa
Enref	125,000 bpsd	Engen Petroleum
Natref	92,000 bpsd	Sasol/Total South Africa (64/36%)
Sapref	180,000 bpsd	Shell South Africa/BP Southern Africa (50/50%)
Coal and Gas Processed and Refined at:		
Sasol Secunda	150,000 bpsd	Sasol
(Crude equivalent @ average yield)		
Gas Processed and Refined at		
PetroSA	45,000 bpsd	PetroSA
(Crude equivalent @ average yield)		

TABLE 2: SOUTH AFRICAN OWNERSHIP AND CRUDE THROUGHPUT

Note: PetroSA has run out of gas reserves. Source: Department of Energy South Africa (2013)

Despite the development of the liquid fuels sector in South Africa there is still an eminent shortage in refining capacity. The country currently consumes approximately 609k bbl/d and has a refining capacity of 485k bbl/d. The shortage of 124k bbl/d could prospectively be addressed with the development of the Mthombo refinery.

The mooted MthomboPort Elizabeth refinery is projected to have the capacity of about 200-300k bbl/d. This would effectively put South Africa in surplus and cater for future demand growth. The project is projected to have substantial economic gains. It is expected to create between 12 000 and 21 000 direct & indirect jobs during construction & between 2 000 & 5 000 when operational (PetoSA, n.d). Despite the announcements of the Mthombo refinery, the development of this refinery remains uncertain as Port Elizabeth has no pipeline connection to the market (Gauteng).

3.4 Refining capacity in other RMCs

Other RMC's account for about 22% of consumption. This equates to about 200k bbl/d and could substantiate the development of a refinery of that size. However, the geographical distances and lack of interconnecting infrastructure make this a challenge logistically. Therefore it is more affordable for these RMCs to import refined petroleum fuels from ex SADC sources until regional investments in infrastructure have taken place. Malawi and several other RMCs have the infrastructural base on which they could build on. Particularly rail and water interconnecting bodies that could be rehabilitated to compete with road transport. This could be done to increase competition with road transport and therefore reduce the price of petroleum fuels.

4 Development of current infrastructure for transporting and refining crude oil and products

'The most outstanding characteristic of the transportation systems of Africa is the comparative isolation in which they have developed within the confines of individual countries and territories. This is reflected in the lack of links between countries and territories within the same geographical sub-region" (United Nations Commission, 1959 in Rodney, 1973 p 355).

This statement sums up the reality in the SADC region. There are limited rail and oil pipeline interconnections in the region. Firms and stakeholders in different respective RMCs face logistical challenges in transporting wet and dry cargo in and around the region (SADC, 2012). Regional bodies like SADC and the EAC are a right step in developing regional infrastructure interconnectors amongst RMCs however there is need for a bigger economic push and commitment from respective governments.

One of the visions of SADC is to develop efficient and seamless infrastructure that connects the region. The island transport systems within RMCs need to be connected to allow for the efficient movement of people and cargo. This could be done through making motion towards the:

- Alignment of strategic intent for an efficient integrated corridor development plan by all stakeholders, operators on rail and water corridors

- Development of a seamless rail logistics corridor that will promote the migration of traffic from road to rail and offer a competitive, complete and integrated rail logistics solution.
- Development of an investment plan that will be used by all rail operators to plan and implement required infrastructure development along the corridor and cater for growing freight volumes.
- Development of an operational strategy which will determine how rolling stock will be designed, acquired, funded and operated across the corridor

Nepad, (2016).

4.1 Malawi: Exploited and unexploited Infrastructure: railway, waterway and trade corridors

The SADC region has several trade corridors that serve the region and provide key interconnections between nations via a combination of road, rail and water transport. Rail infrastructure was primarily developed in colonial eras to transport capital goods, minerals and labour between colonies. It was largely centred on mining activities (Rodney, 1973). These interconnections provide an insight on how liquid fuels are traded and transported to landlocked countries predominantly Malawi, Zambia and Zimbabwe. These interconnections further form a basis on how best these resources could be traded and transported amongst landlocked RMCs in the region (SADC, 2012; Kalinga, 2011).

Malawi utilises four transport routes for liquid fuels to enter the country namely: the Nacala road/rail transport corridor, the Tanzanian road transport corridor, the Beira road transport corridor as well as the Beira rail corridor that stretches to Blantyre (Limbe). The Beira rail corridor has connections to Salima (Chipoka port). It then stretches to Lilongwe and finally to the Zambian border post. Industry players utilise these three routes to ensure the continuous flow of liquid fuels given the realities of political instabilities and diplomatic tensions that flare up from time to time between nations (Kalinga, 2011; CEAR, n.d.).

Malawi is reliant on Tanzanian and Mozambican ports to service the country for liquid fuels. The lack of refineries in the region means Malawian oil industry players have to import refined petroleum products from Singapore, India and other countries that have a surplus refining capacity (Redvers, 2013). The purchased petroleum products are then transported to Beira and Nacala ports. Petroleum products are then transported by road to southern central Malawi and then distributed in the country by road transport(Jica, n.d).

This dynamic has created a trucking community in the country that is a very powerful lobby that attracts rent seeking politicians to invest in and promote the industry by adopting certain policies that favour road transport over other modes of transport that could compete, and otherwise reduce the cost of transporting fuel (Kalinga, 2011;Cilliers&Mashele 2006; Lall et al, 2009).

Re-evaluating this paradigm offers some key economic insight as to how these unexploited infrastructures could be exploited and developed to reach better economic outcomes. Figure 8 shows a map of railway and road infrastructure available to the SADC region.

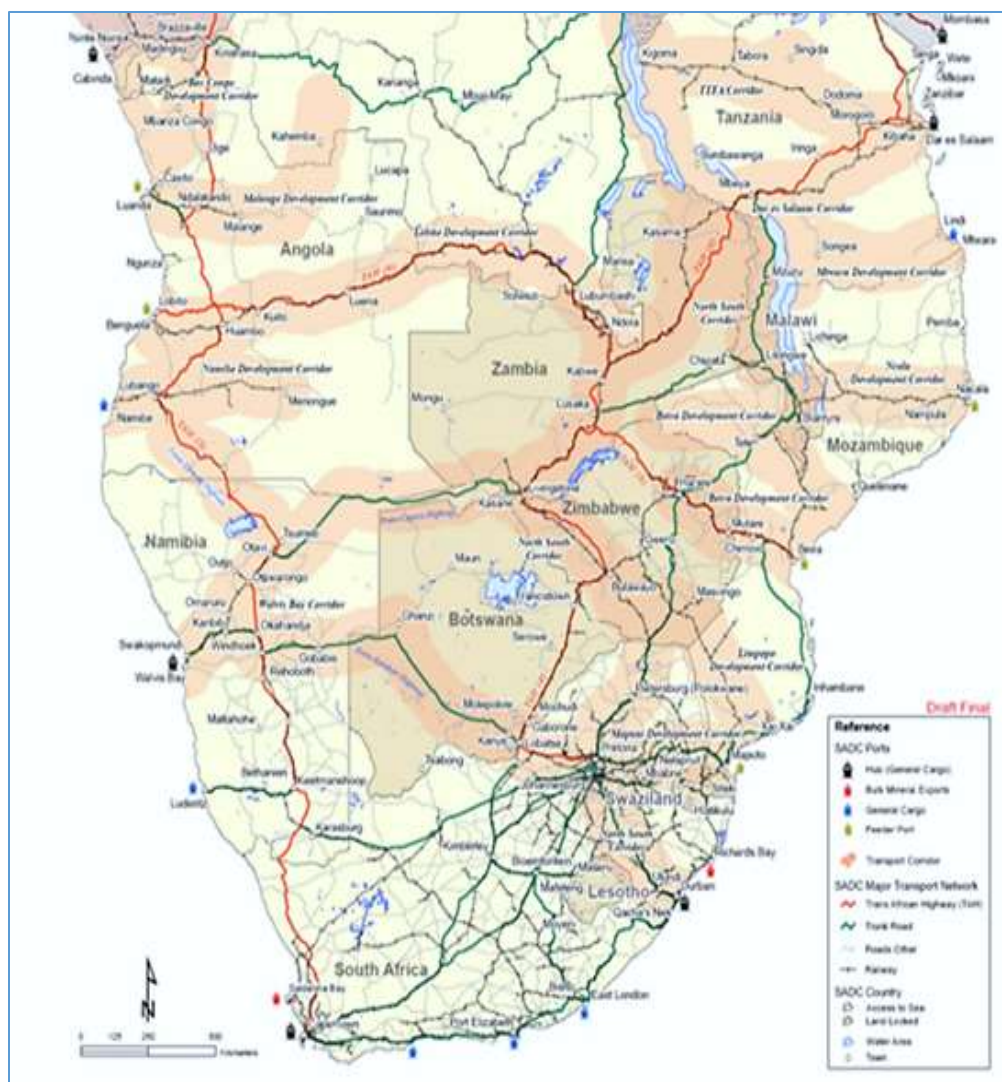


FIGURE 8: TRANSPORT INFRASTRUCTURE MAP

Source: SADC, (n.d)

4.2 Railway routes to Mozambique

Malawi has both rail and water inter-connections with Mozambique. The Nacala corridor has opened up the central corridor that connects Malawi to the port of Nacala and gives Malawi access to the sea. Theoretically it should be cheaper to transport liquid fuels via rail directly from the port in Nacala however rail in SADC has been characterised with several challenges including delays, inadequate infrastructure and the handing over of freight to other locomotive companies in different RMCs (Nepad, 2016).

The Malawian and Mozambican rail operations are operated by CEAR a company which is controlled by Vale as per Vale's 51% acquisition of the NacalaRail Development Company in 2010 (AFDB, 2015). Therefore it could be expected that some of the challenges will be limited if it is run and regulated efficiently as there is one operator controlling freight in both countries. There is also a challenge with having CEAR as the only operator on the Nacala corridor as the company may limit how much capacity is given to other general cargo (Nepad, 2016). There is therefore a need for strong regulation from both governments to ensure that CEAR does not abuse its market power. The Nacala rail development has further spurred the development of the Liwonde inland port. The inland terminal will accommodate transit freight that is destined for Malawi and also to handle future export commodities that are destined for the Moatize region (AFDB, 2015).

The southern corridor connects Malawi to the port of Beira. This is also an alternative route to transport liquid fuels from Mozambique to Malawi. The road link to Beira is utilised heavily, however the rail remains underutilised in Malawi. The section in Donna Anna (Mozambique) that links the Mozambican rail to the Malawi rail was cut off but has since been rehabilitated and deemed to be in a fair condition (Jica, n.d). The Sena rail has the capacity to carry 6 Mt/y tons of cargo and once utilised effectively by Malawi, will provide a valuable alternative corridor that will complement the Shire Zambezi waterway (if it comes into operation).

4.3 Shire Zambezi waterway Malawi and Mozambique

The Shire Zambezi Waterway is a historical route that early European settlers used to access and explore the region. The waterway flows from the Indian Ocean north into the Zambezi River from the Mozambican port town of Chinde. The Zambezi meets one of its main tributaries: the Shire River; that connects Malawi and Mozambique (Kalinga, 2011).

The Shire Zambezi water way project has interested Malawian, Zambian and Mozambican governments for reasons affecting the affordability of cargo. Cargo destined for Malawi and Zambia would be cheaper to transport via this route as

opposed to the predominant road transport that is currently utilised from Mozambican ports. The feasibility study that was carried out concluded that the development of this route is technically feasible however the viability and long term sustainability rests on the investment and coordination of the beneficiaries of the project: Malawi, Mozambique and Zambia (African Water Facility, 2011; Canhangwa, 2014).

4.4 Tanzania waterway and rail connection and TANZAM pipeline

Tanzania and Malawi share a water body, Lake Malawi. North of Lake Malawi is the TAZARA railway line that connects the port of Dar es Salaam to the Copperbelt of Zambia. This railway line passes through the town of Mbeya 126km north of the Chilumba port (Kalinga, 2011). This port has both road and rail connections into Zambia and eastwards to Dar es Salaam. This infrastructure provides a significant transport route both to access markets and source raw materials for industry. The TANZAM pipeline runs through Mbeya before proceeding to the Ndola refinery.

The former regime of Kamuzu Banda invested in some key infrastructure to transport liquid fuels available to Malawian authorities. Storage tanks were built in Mbeya to store refined petroleum products for Malawi. The MV Ufulu is a water tanker that was also purchased to transport liquid fuels in the country from north to the south of Malawi. (Kalinga, 2011; SADC, 2011). The growth of competition from the trucking industry coupled with the underinvestment in the Lake Malawi transport service, led to the running down of these facilities.

Consequently, Malawi has one of the highest pump prices for liquid fuels in the region. This is because of the inadequate maintenance and utilisation of infrastructure for transporting liquid fuels. The government levies are also high due to the limited tax base (low bbl/d requirement). The flow of this price build up is shown in Figure 9.

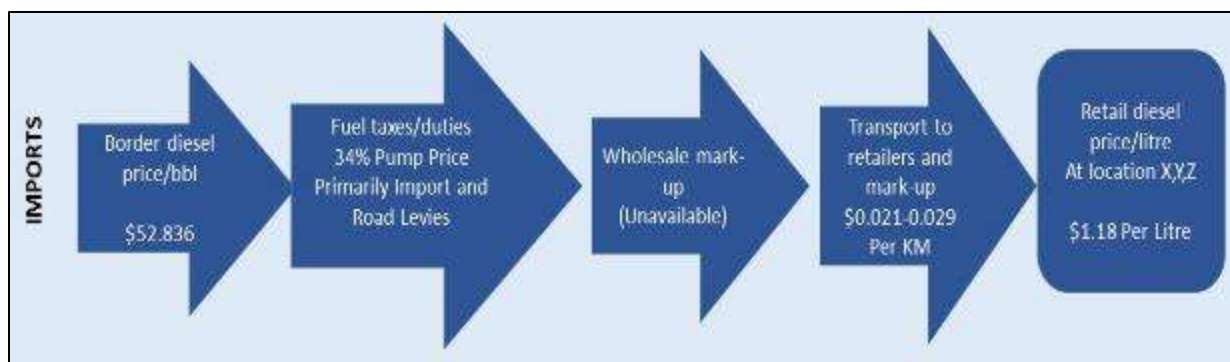


FIGURE 9: PRICE BUILD OF IMPORTED PETROLEUM PRODUCTS

Source: Malawi Energy Regulatory Authority, (2016)

5 CTL/ GTL

Historically CTL technologies have been utilised in periods of crises and conflict due to the costs associated with developing these facilities, relative to conventional liquid fuels. Fortunately, today with technological advances these facilities have become modular and consequently, more economically viable for developing nations to pursue in achieving their liquid petroleum goals. Botswana, Malawi and Ethiopia are exploring the adoption of utilizing CTL and GTL technologies (Malawi Ministry of Trade and Industry, 2014; Holland Hauseberger, 2015). If implemented effectively this will be a strategic move toward strategic import substitution industrialisation. A modular CTL facility would not only produce liquid fuels but also other petro-chemicals that could be fed into other industries such as fertiliser production, plastics and polymers and the syngas could be utilised for power generation (Vallentine, 2008; Alfstad, 2015; Malawi Ministry of Trade and Industry, 2014). Figure 10 illustrates this process.

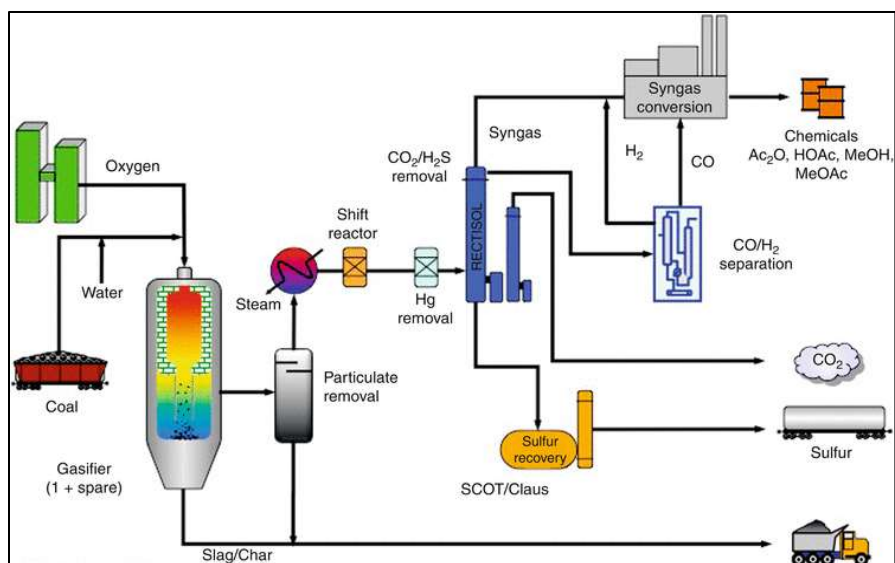


FIGURE 10: SIMPLE CTL FACILITY.

Source: encyclopedia of sustainability science and technology,(2012)

5.1 CTL /GTL a case for Malawi

Malawi has a limited industry and is a small consumer of liquid fuels. Malawi consumes approximately 10k bbl/d of liquid fuels (petroleum & diesel) (EIA, 2015). Much of this is used to power motor vehicles for transportation rather than to power heavy industry. The problem with this is that Malawi and much of the SADC community import refined products at a higher price per barrel, because of lack of transport infrastructure in the region that increases transport costs. However,when considering this technology one has to consider the size, scale, transport routes, sources of raw materials and country legislation to assess the economic viability of such an investment (FT expert, personal communication, February 19, 2016).

5.2 Size and scale

The challenge with Malawi (as highlighted earlier) is that the market size is relatively small(approximately 10k bbl/d). One could consider the market in Tete, Mozambique, Zambia and possibly Tanzania. Legislation in Malawi does not allow for export of petroleum products (Carter, 1997). This was a historical law that was aimed at protecting the petroleum supplies that are imported into the country, to reduce room for arbitrage between Malawi and its neighbours. Consequently a CTL solution that serves

domestic requirements is more suitable for Malawi(Anonymous FT expert, personal communication, February 19, 2016; Sparks, n.d.).

Modular plants are not constrained by the initial size of the plant as they can be upgraded at later stages to accommodate for local consumption increases or increases in the demand of neighbouring countries (Golinska& Kawa, 2015).CTL facilities require continuous supplies of coal and therefore aside from domestic resources RMCs wishing to establish CTL technologies need to consider alternative supply options of sourcing coal. Malawi has supply options in Tanzania & Mozambique.

5.3 Raw Material Sources of Coal: Tete, Moatize Coal reserves

Estimates of coal resources in Mozambique are uncertain. BGR estimates Mozambican coal reserves of 23 Gt. Recoverable reserves are estimated to be at 849 Mt, which comprises a mix of thermal (25–30%) and coking (70–75%) hard coal (Bayura&Kessels, 2013). VALE plans to increase their production to 20 million tonnes a year. This will require added capacity which is expected to cost a further investment of \$4.4 billion (Bayura&Kessels, 2013). Vale in conjunction with CEAR has constructed the aforementioned Nacala rail that passes through Malawi. Nacalais considered to be a more viable deep sea bay for the deep sea vessels versus the other ports, for example the port of Beira(Sena line) hence the development of the Nacala rail(Campbell, 2013).

Some of the Tete coal is available to Malawi. Part of the agreement between the Malawian and Mozambican authorities and VALE SA was to provide the Malawian government with a concession to transport a certain tonnage of coal on the railway line for use in Malawi and once fully operational, the Nacala corridor will earn the Malawi government \$8 million a year (Scholvin&Plagemann, 2014). This particular concession would contribute to the quantity of coal reserves available for CTL facilities in Malawi. Figure 11 shows the route of the Nacala corridor.

In addition to the above, the Moatize coal mine contains coking coal a primary resource that is used in steel production. The price of coking coal is higher than the price of the normal steam coal. However for the mining companies to access this coking coal they have to remove the steam coal that lies on top of the coking coal. Primarily the steam

coal is waste coal and could be marketable to overseas markets with cleaning to achieve the requisite quality attributes, but attracts a much lower price (FOB port). Therefore the steam coal would best be beneficiated locally for the Mozambique market or for surrounding markets. One way to utilise thermal coal is to use it in power generation, CTL/GTL technologies or in a combination both power and liquid fuel production.

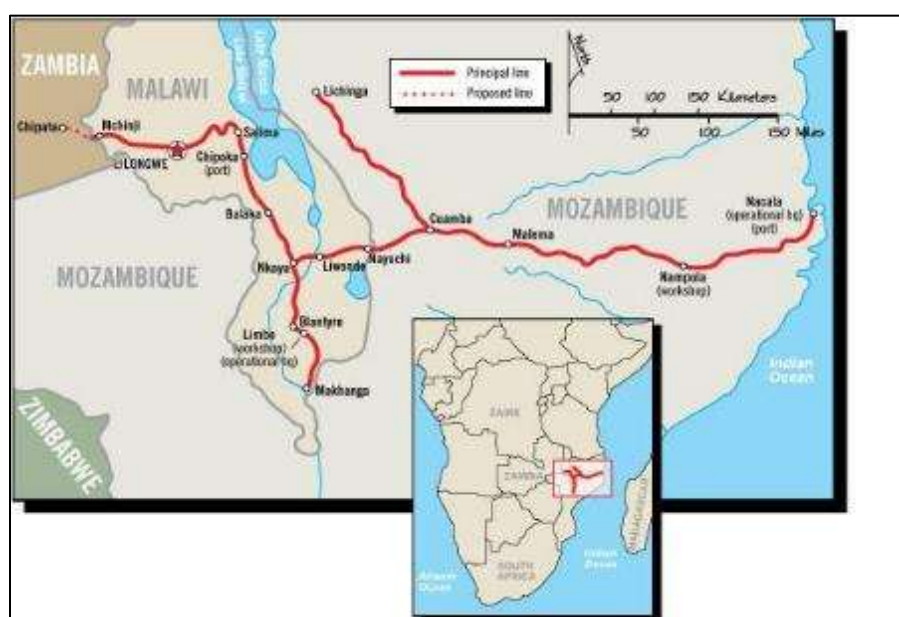


FIGURE 11: NACALA-MOATIZE RAILWAY MAP

Source: Hudson, (2009)

5.4 Raw Material Sources of Coal Tanzanian coal reserves

Tanzania hosts approximately 5 billion tonnes of proven coal reserves in Tanzania (Dodson, 2013). The coalfields with the highest potential are Ketawaka-Mchuchuma in the Ruhuhu basin, Ngaka fields in the south-west of Tanzania and the Songwe-Kiwira fields (Dodson, 2013). This coal is primarily used for domestic use and power generation. With the revised coal reserves, the country plans to increase its coal-fired power generation capacity and could potentially increase current levels of exports (Dodson, 2013). The addition to the reserves has attracted Investment from China, Australia and from the Dangote group to develop coal power plants in the country.

This added investment will increase Tanzanian coal mining production and could potentially provide an alternative avenue for sourcing the coal. The Ngaka coal fields

are in close proximity to Malawi's northern rail and water corridor. Although this corridor is underutilised by Malawian industry players, it could prove to be a competitive solution to transport coal into the country and petroleum fuels out of the country. The increased production in Tanzanian coal mining activities will increase output and there could potentially be a surplus of coal that could be exported to Malawi for CTL conversion processes in future. Figure 12 shows the route of the northern corridor.

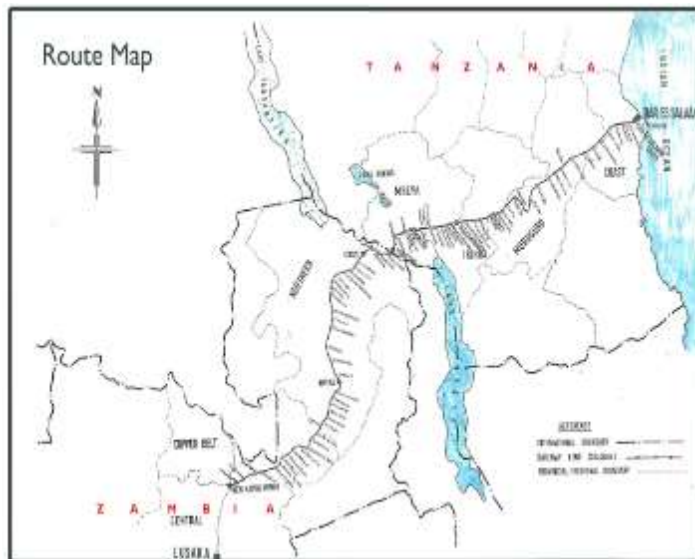


FIGURE 12: THE TAZARA RAILWAY LINE

Source: Zambia Railway authority, (n.d.)

5.5 Raw Material Sources of Coal: Malawian coal reserves

Malawi has estimated coal reserves of 800 million tons (Malawi Ministry of Mining & Energy, 2009). Most of the economic grades of coal are located in the north of Malawi and have a lower ash content making the northern coal reserves less denser and therefore, more viable for CTL processes than coal resources in the south (Cairncross, 2014). Coal resources in the south could still be used, it simply means that due to the lower quality attributes more coal per barrel would have to be used than the coal reserves of the north (Ministry of Energy & Mines, 2015).

Currently, Mchenga is the biggest coal mine in Malawi. It operates at a capacity of 5000 tons of coal per month (60kt/y); suggesting that the coal reserves in Malawi are largely unexploited. Nonetheless, like in the case of Mozambique one would have to utilise the

transport infrastructure available: waterways, rail and road that have already been discussed.

5.6 Economic viability of Raw Material Sources

The aforementioned sources of coal are all potential sources however there are three main primary locations that are potentially strategic because of the availability of low cost coal. The first strategic location to construct a CTL facility would be in Tete. The second strategic location would be to construct the CTL facility in Mwanza 300kms north-east of Tete that relies on the transportation of Tete coal into Malawi. The third option is to construct the facility based on indigenous coal reserves at coal mines in the north or the south of Malawi.

5.6.1 CTL Facility in Tete for Mozambique and Malawi

The Moatize coal reserves contain coking coal that attracts a higher FOB price than steam coal. In order for mining companies to access this coking coal they have to lift a considerable amount of thermal coal off the roof of the mines. This consequently makes the thermal coal a waste product for the mining companies. The thermal coal attracts storage costs and creates safety hazards as coal is pyrophoric. Therefore, by companies storing it in large storage facilities they run the risk of fires developing in the mining facilities. It is therefore likely that mining companies will be willing to flog the coal at very low prices. Consequently, a regional CTL facility based in Tete would have access to an abundant cheap source of coal (Global CCS Institute, n.d).

The reduction in transport costs (that would otherwise accrue if the coal was bought and transported to Malawi) would increase the viability of the project and could potentially motivate the development of a product pipeline to transport refined petroleum fuels to Malawi. Currently Malawi falls under the SADC umbrella and certain goods are exempted from import taxes. Currently there is no legislation governing the importation of fuel that is manufactured in Mozambique because there is no petroleum production in Mozambique. Negotiations with government officials will therefore have to take place to strategize how the developer could access the Malawian market and to assess the willingness for Malawi to participate in the development of a facility under a joint venture

agreement that would increase the scale and demand of the market. It is however unlikely that the government of Malawi would be willing to forego tax revenues that are earned by the importation of petroleum fuels if the financial gains from the CTL facility are not greater than the current earnings. The second alternative for Malawi is to purchase the coal from Tete and transport it to Malawi via the Nacala corridor (Malawi Energy Regulatory Authority, 2016: Malunga&Phalira, 2014).

5.6.2 CTL Facility in Mwanza Malawi

Constructing a CTL facility in Mwanza would attract transport costs that make the project less economical than developing the plant in Tete. However, if legislation is drafted that makes petroleum products produced in Mozambique liable for an import levy then the viability of setting up this facility in Malawi based on Tete coal increases as currently coal is duty free and locally produced fuel would not attract an import duty. The third alternative is to set up the facility based on Malawian coal reserves (Malawi Energy Regulatory Authority, 2016: Malunga&Phalira, 2014).

5.6.3 CTL Facility based on Malawian Coal

Mining production in Malawi has remained at relatively low levels of output. Economic analysts have raised concern over the duty free tax on coal imports. The negative performance of coal mines is partly attributable to the inefficiencies in local coal mining operations that consequently mean that local mining companies find it difficult to compete with foreign competitors. A CTL facility would increase the demand for local coal however it would require recapitalization of local mining companies in order for them to increase their annual production. This would increase the price of coal per ton as local coal miners would have to charge a premium price for the coal in order to service debt and operations and because the coal would be a primary commodity (not a waste commodity as in the case of Tete coal)(Chikoko,2016: Global CCS Institute, n.d).

Therefore the success of the project and chosen strategy is ultimately dependent on the alignment of political interests with commercial interests. The project promoter would have to negotiate with policy makers both in Mozambique and Malawi in order to assess the willingness of the governments to harmonize their petroleum policies. At this point in

time a CTL plant located at the Tete coal reserves appears to be the most strategic location to develop a CTL plant because of the availability of the raw material.

5.7 Capital requirements and funding and pricing models

Building this sort of industry requires large capital requirements and investor support. SASOL have recently announced that they will not be developing anymore large CTL facilities due to the environmental impacts of their chemical processes. SASOL's focus is therefore expected to be on developing GTL technologies that pose less environmental problems. This effectively suggests that SASOL funding will flow to Mozambique, Tanzania and other countries that have recently discovered large natural gas reserves (Radebe, 2012).

Given Malawi's economic woes at the moment, the government is not in a position to commit any financial resources of their own. However, the Malawian government is willing to offer political support in terms of providing land, tax breaks, import parity pricing models, offering land for development and in negotiating offtake agreements (Ministry of Trade & Industry, 2014).

In order to obtain funding and increase the viability of a project of this scale, developers are put in a better position if they obtain offtake agreements that guarantee that government will purchase the product produced. In this case negotiations on offtake agreements range from petroleum products, electricity, polymers and plastics, sulphur and other by-products (Nepad, 2016).

However, as highlighted before, the success of PPPs and economic distribution largely depend on the cooperation between the public and private sector participants involved in negotiations. Without this cohesion the sustainability of such a project is not particularly convincing (SADC, 2011). Malawi's experience with the Kayelekera uranium mine has provided key lessons for government and has shed light on the importance of the cohesion of public and private sector participants (Banda, 2015; Amsden, 2007).

5.8 Economic Benefits of CTL in Malawi

5.8.1 Reduction of the Malawian importation Bill

Petroleum products and chemical fertilizers are amongst the top two imports for Malawi. Currently Malawi relies solely on imported refined petroleum products. The country imports about 8 000 barrels per day while the average daily fuel demand is currently estimated at 1.124 million litres which translates to 33.6 million litres per month or annual budget equivalent of US\$366 million (Lanjesi, 2011). The import bill has been continuously increasing in recent years which imposes a serious financial burden on a developing country that already suffers the problem of huge public debt. A major consumer of the liquid fuel is the transportation sector (89.99%), followed by domestic (5.25%), industry (2.87%), and agriculture (1.9%) (Phiri, 2006). The second largest export in Malawi are chemical fertilizers (Tauro, Gondwe&Adoniya, 2015: Kamphanje, 2012).

Malawi is an agrarian economy that relies on subsistence farming and some commercial agricultural farms. The fertilizer subsidy was introduced during the BinguWaMutharika regime. Initially the program was faced with a lot of criticism however the total production that year put Malawi in surplus and resulted in exports to Zimbabwe. This policy stance has been implemented year on year and has become a politically motivated policy. The Malawian government allocates about \$128 Million to the Fertilizer Import Subsidy Program and this too is a relatively high figure for a developing economy. A modular CTL facility has the potential to alleviate some of these issues (Tauro, Gondwe&Adoniya, 2015: Kamphanje, 2012).

5.8.2 Beneficiation of By-products: Linkages into fertilizer production and opportunities for supply industries

The conversion of coal to liquid fuels technology has issues of high capital costs, environmental concerns, potentially high price floors (depending on the volatility of the oil price) and the cost of importation of coal. Nevertheless, a modular facility that can cater for Malawi's fuel needs would effectively reduce the burden on the import bill and save the country much needed foreign exchange provided capital controls are in place to prevent the extortion profits. If profits are invested locally the by-products: nitrogen and ammonia could motivate the development of a chemical facility complex in phase two of the development of the project. This would alleviate Malawi's dependence on imports significantly and allow for foreign earnings to be devoted to other critical areas such as health and education (Tauro, Gondwe&Adoniya, 2015: Kamphanje, 2012).

Additionally, the development of such a facility will require the development of support industries in terms of consumables and other inputs. These upstream requirements can offer opportunities for indigenous entrepreneurs to set up businesses that integrate into the CTL facilities supply chain. Figure 13 summarises how the aforementioned facilities can be developed and illustrates linkages between them.

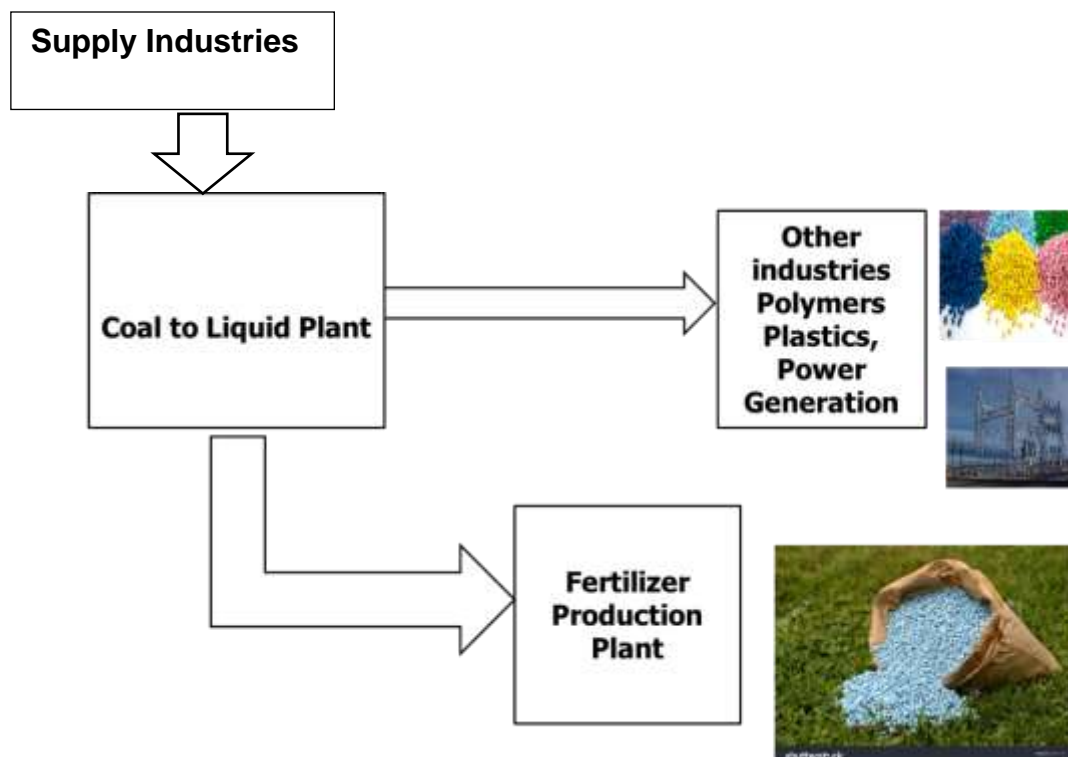


FIGURE 13 SUMMARY OF PROJECT INDUSTRIAL LINKAGES

5.9 Environmental Concerns of CTL

CTL facilities produce a higher carbon footprint than conventional fuels because in order to produce the liquids the process requires the burning of energy which in turn increases carbon emissions. Once the fuel is produced, the carbon therein is emitted when is consumed in combustion engines. Given the environmental concerns, international organisations are hesitant to fund projects that emit carbon. This could be a challenge for Malawi; however, given the countries low carbon emissions (due to the low industrial base), there is room for the country to manage its carbon emissions within its limits. If a regulatory institution is developed, further environmental concerns can effectively be managed to curb and reduce environmental impact.

5.10 Import Substitution Industrialization in Malawi in CTL

The ISI policy stance could be beneficial for Malawi in this sector however there are socio-economic dynamics and theoretical insight of ISI that should not be ignored.

The import substitution theory rests on the idea of developing nations becoming self-reliant by developing local infant industry to a point where domestic products can compete with imports. Nations have utilized a variety of devices that are protectionist in nature including nationalization policies, high tariffs, direct investment from national governments and over-valued exchange rates (Baer, 1972). Benefits of ISI include job creation and skills development as foreign production is substituted for domestic production (Kulkarni, 2009). Critics of this economic policy argue that protectionist policy reduce dynamism and therefore limit the access to cheap exports therefore departing from theories of comparative advantage that argue that nations should focus on the factors of production that their endowed in and trade those for other goods and service in order to achieve economic growth (Kulkarni, 2009). (Amsden, 2007) however argues that developing nations should adopt big push unbalanced growth models and engage

in industrial activities that they have no comparative in order to increase their industrial capabilities and linkages into the industrial sector.

Although Malawi and other developing nations may well want to embark on this economic policy route as a way to grow their national industries, most are riddled with high public debt ratios, donor reliant funding and private investment to fund their socio economic sectors and to rebuild their infrastructure (Amsden, 1999). Depending on where the funding is sourced from there are usually conditions tied to procurement procedures that usually favour the home country developers. This effectively results in limited local participation by the host country population and if any is usually at the low skilled levels. This effectively limits skills and technological transfer. Therefore, the form ISI can take for developing countries in the 21st century is heavily reliant on the political will and their governments ability to negotiate and approve key projects that maximise economic linkages and that maximise local participation in order to assist in creating a pool of skills that can effectively operate and develop these technologies further maintain them once concessions with private developers and operators have expired. The length of the concessions granted must also be negotiated to ensure a facility taken control within its useful life (Chang, 1999: Baer, 1972: Pahariya, 2006).

5.11 Development of current CTL facilities in SADC

It is positive to note that national governments in the region are taking a key interest in these technologies to address the liquid fuels security issues that have been a major socio-economic challenge in the region. A 20000 barrel/day investment is being assessed out in Botswana that will ensure energy security in terms of liquid fuels in the country (Holland & Hauseberger, 2015). It will further give the economy of Botswana a yearly 830 million USD balance of trade benefit. The project has high socio-economic impact as construction spans 5 years and has an employment requirement of between in excess of 5000 at construction phase. This will provide significant employment opportunities for the Botswana economy that is no exception to the issues of youth unemployment. The total investment is about 4.2 billion dollars and is not limited to the production of liquid fuels alone (Sparks, 2013).

Botswana is in advanced stages as it has been announced that Coal Petroleum will commence with this project. Other RMCs that do not have CTL technologies could soon follow, however it is important for RMCs to monitor the developments in Botswana and infrastructural upgrading projects in other RMCs, as there could be over capacity if investment is not coordinated with a regional aim (SADC, 2012).

This interplay could provide key insight to import-substitution industrialisation in the SADC energy sector and perhaps will lead to the conclusion, that some ISI-scholars reach, that it works to a certain point and then collapses unless the markets open up; the case of Latin America (Amsden, 1997). Or it could lead to different conclusions and provide key lessons of the lessons of regional ISI in the SADC energy sector given the young levels of industrial development in Africa (Khan, 2010). Figure 14 shows how the development of a small scale CTL industry could be developed. Significant state support is necessary to apply import parity pricing mechanisms, offtake agreements amongst other political support that will increase the viability of this project.

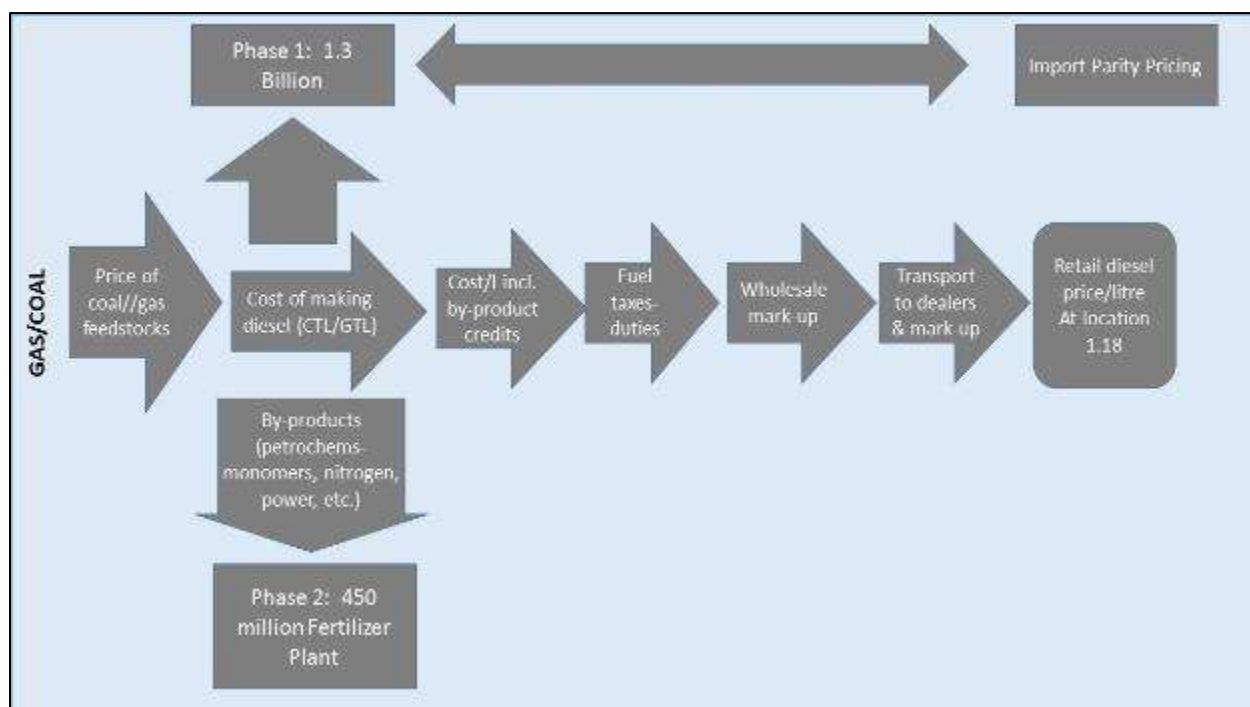


FIGURE 14: FLOW CHART CTL DEVELOPMENT MALAWI

Source: Malawi Energy Regulatory Authority, (2016); Ministry of Trade & Industry, (2015)

5.12 GTL

Natural gas discoveries in the Rovuma basin off the coast of Mozambique/Tanzania have attracted significant attention and investment. Anadarko have concessions on two blocks of the Rovuma basin. Anadarko and ENI are key players that are looking to develop blocks one and four. In order to make it practical and commercially viable to transport natural gas from one country to another, its volume has to be greatly reduced. To obtain maximum volume reduction, the gas has to be liquefied (condensed) by refrigeration to less than (Anadarko, n.d.).

Consequently the USA and Italian companies are looking to establish two LNG trains each in Palma. These developments have interested companies like Sasol to develop GTL Plants in Palma. These projects pose significant economic gains for Mozambique however there are socio-economic issues and lessons that the Mozambican policy makers would have to consider to prevent the effects of Dutch disease (Mathews, 2014).

The global decline in commodity prices has affected the viability of non-conventional projects of producing liquid fuels. Many tar sands and tight oil projects in North America have gone bankrupt with the current low oil price of \$30-\$40 per barrel (Golinska & Kawa, 2015). CTL and GTL technologies also require a price greater than \$50-90, thus these projects are also negatively affected.

5.13 Commodity price indices

The global market has seen an economic slow-down. Commodity prices were largely driven up from the 1980s, 1990s and 2000s by the industrial growth of eastern Asia. The 2008 financial crises that began in America and affected the global market brought about a reduction in commodity prices. Metals and energy prices have (for the most part) decreased and are projected to decrease further (World Coal, 2016). This has had adverse impacts on non-conventional energy projects as the viability of such projects rested heavily on the historical high price of energy.

At these lower prices it is not economically viable for investors, as it is difficult for them to compete with conventional sources of oil. If Saudi Arabia increases output, lowering the

oil price, it consequently drives out investment the non-conventional sources of oil projects (Golinska& Kawa, 2015; Soderbergh, Robelius&Alekklett, 2007). It is important to pay attention to this dynamic and volatility of the price energy in assessing the viability of such CTL/GTL and other non-conventional sources.

Price and income are not the only economic goals: there are other matters of national interest to consider such as domestic production to aid liquid fuels security and balance of payments. Naturally there is interplay between private and public sector interests, so it is a matter of balancing these interests and prioritizing goals to assess the viability of such projects (Amsden 2007; Index Mundi). Figure 15 shows the trend of commodity prices since 1992-2015.

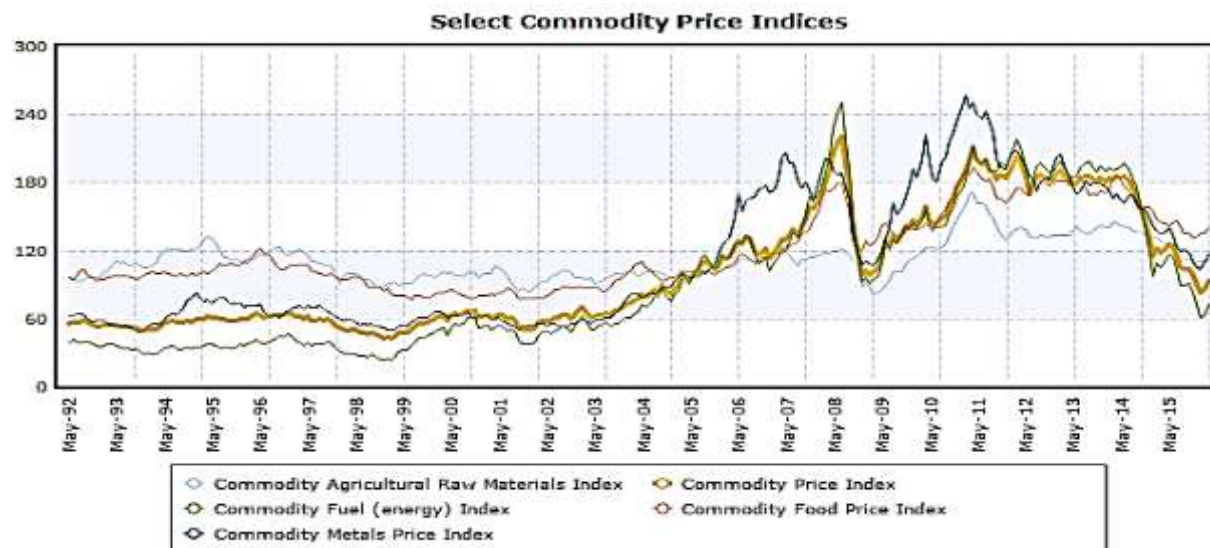


FIGURE 15: COMMODITY PRICE INDICES

Source: Index Mundi,(2016)

6 Biofuels

In the early 19th century when the early inventors were developing the first engines that the world would grow dependent on, Rudolf Diesel developed the first vegetable oil run engine. Comparatively, it was more efficient than the petroleum powered engine of that time. He however died a mysterious death on his way to present his engine to one of the biggest motor shows of that time (Bryant, 1976). Massive lobbying by firms that had

controlling stakes in the oil industry took place to persuade governments to opt for the oil and diesel engine instead of the bio-diesel powered engine. Nevertheless, in recent times, with the limitations of fossil fuels becoming more apparent than they were historically, a significant rise in global interest and production of biofuels has taken place; creating room for significant investment in unexploited regions of sub-Saharan Africa (Polasky, 2009). Unlike conventional petroleum based energy, biomass is not concentrated in a few countries and is uniformly distributed amongst all nations in the world. Every nation produces:

- Agricultural waste; and
- Agricultural crops.

The key factor and difference in utilisation are the technological expertise and coordination between public and private sector participants in different countries (Khan, 2013; Antoineli, Amidei&Fassio, 2014).

[6.1 Biofuels a case for MalawiSize Scale](#)

According to EIA statistics Malawi imports 9.2 k bbl/d. EIA, 2015). A 200 million litre biofuel facility would require an investment value of \$150 million and a similar project is currently under way in Queensland, Australia (Queensland Government, 2016). There is also a further range of pilot projects across Africa. The primary feedstocks for biofuel production include sugar fluids, Jatropha, soy beans, maize oil and waste, amongst other others. However there are some socioeconomic debates that tie into some of the oil seeds. Figure 16 shows the major feedstocks of biodiesel.

6.2 Potential feedstock for biodiesel production in Malawi

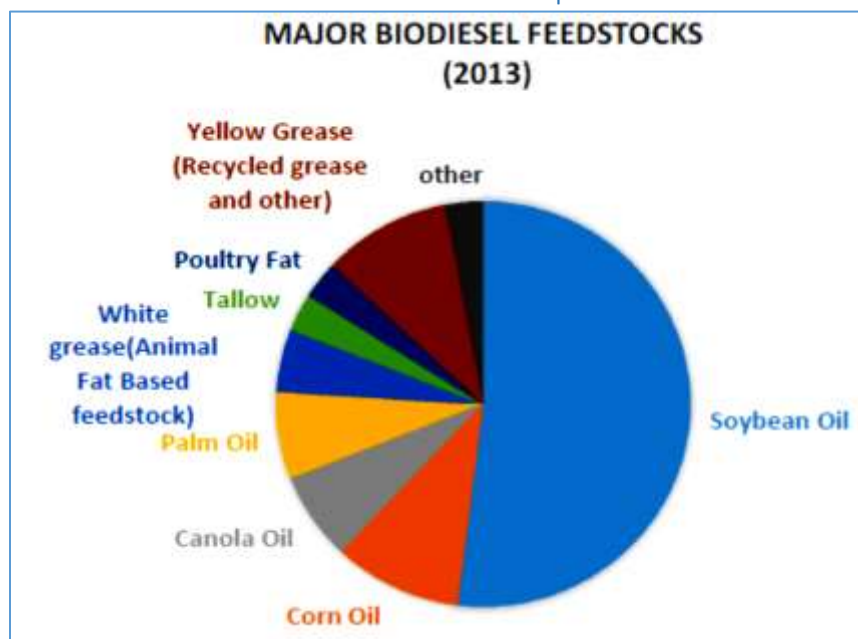


FIGURE 16: MAJOR BIODIESEL FEEDSTOCKS (2013)

Source: EIA, (2013)

According to the Energy Information Agency (EIA) statistics of 2014 the main crop based feedstock were soybean, corn oil (in the U.S.A), canola oil, palm oil, amongst others. Soybean was responsible for about 50% of all biofuel production in the world. The Malawian government in 2013 rolled out initiatives to increase soy production by providing incentives such as providing the inputs (seeds, fertilisers) as well as engaging in offtake agreements with farmers (EIA, 2014).

Soya beans are rich in oil and the cake is very nutritious and rich in protein. It is a critical food crop that is farmed extensively in Malawi and other nations in the region (Mullan, 2012). It is mostly processed into cooking oils, meat substitute's, breakfast cereals for infants and for hospital patients as well as animal feeds of which the surplus is exported. Soy is a rich and ideal feedstock for biofuel production. Although the food displacement argument may apply here, as there is indeed an eminent food shortage, one could source the soy from outside Africa if supported by tax exemptions for importing the product.

Tobacco is one of Malawi's main cash crops. The airline industry has expressed interest in greener jet fuels. Skynrgis a Netherlands based company that has genetically engineered a tobacco seed called Solaris. Once the tobacco seed has grown it produces an oil seed that has similar attributes to the jatropha oil seed. It is being rolled out to large scale tobacco farmers for mass production (ProjectSolaris, n.d).

Sugar cane is another major crop in Malawi. It is grown in the Shire Valley on extensive estates. Brazil has succeeded in producing bio-ethanol from sugar cane to a point where it is more affordable than conventional petrol at pump price due to tax differences and government support (Hall Matos SeverinoBeltra, 2009). Malawi and other RMCs could get valuable insights from Brazil's biofuel policy (Mullan et al, 2014; Mkandawire, 2010).

Illovo sugar is actively producing ethanol from sugar cane in Malawi. Illovo's ethanol production is however limited as the company does not produce it commercially. It is mainly to power their machinery for factory operations. This forms a basis for the government to engage Illovo to commercially produce ethanol through incentives and harmonisation of energy and agricultural sector policy frameworks. Illovo does not always utilise all of their available land and usually have extra planting capacity. Therefore plans could be developed for Illovo to utilise their extra fields with the guarantee that government or other private sector firms will buy production, whether it be sugar cane for ethanol or maize for biodiesel production. This economic arrangement was done before in 2010 (for food production not biofuels) but has not been repeated by the stakeholders (Illovo, 2013).

Maize (corn) is a major crop all over the world and it is used as a staple food in most dishes across southern Africa. It is also a crop that can be used as a feedstock for both ethanol and biodiesel production (UNDP, 2010). However using maize for bioethanol and biodiesel has the potential to cause serious social issues as this is a key food crop and in Africa food security is at the centre of economic policy. It would be rather unreasonable to consider this as a suitable feedstock for biofuel production unless it

could be sourced cheaper from elsewhere in the world at more competitive rates than the revenues from biofuels (Mullan et al, 2012).

Another important non-edible plant that has been studied extensively is *Jatropha carcus* (JC) (Aransiola et al, 2012; Aransiola et al., 2013). This crop can be planted on fields or as a boundary crop (fence around fields). It can grow even on land where normal cultivation crops fail to thrive (Mullan et al, 2012; Gui et al, 2008; Kuntashula Vermeylen, 2014). The private company Bio Energy Resources limited is encouraging rural communities to plant *Jatropha* as a boundary crop on a contractual farming basis (Berl, n.d.). *Jatropha* is inedible therefore food versus fuels debates do not apply to this particular crop. Table 3 shows the major feedstocks and their prospective yields.

	Sugar	Sugar molasses	Sweet sorghum	Maize	Cassava	<i>Jatropha</i> ²	Palm oil	Soybean	Canola	Sunflower
Litres fuel/t	60-80	240	40	366-470	160	350	230	227	400	400
Tonnes/ha ¹	13-105	4.5	60 ¹	1-5 (USA) 9	3-8 (Thai) 80	2-8	20	2.67	1.4	1-2.5
Biofuel yield l/ha	780-8400	1080	2400	366-3760	480-1280	700-2800	4736	446	552	400-1000
Petrol equivalent/ha	3833	756	1680	2625	1304					
Diesel equivalent/ha						690	4451	420	550	660
High protein animal feed as a byproduct	no	no	no	yes	no	no	no	yes	yes	yes

TABLE 3: INDICATIVE YIELDS AND FUEL EQUIVALENTS FOR COMMON BIOFUEL FEEDSTOCKS

Source: Malitiz, Mapako & Brent, (2009)

6.3 Potential development and growth of biofuel industry in Malawi

In assessing the potential growth of biofuels in Malawi it is important to consider the implications of the reproduction of biofuel feedstocks in Malawi. With most of the population depending on the agricultural sector, it is important to consider how the agricultural sector could be enriched and sustained economically and geographically to meet food and energy requirements.

Malawi is, a country with a climate and soil composition properties similar to that of parts of Brazil. Brazil is the home of the “*Cerrado miracle*” which saw a boom in soy

production by a process of enriching what was seen as unusable arable land (Gao et al, 2008). This similarity in soil and climate suggests that Malawi could adopt a similar policy to increase soy production. Sugar cane production could be increased by engaging with private sector participants in Malawi (e.g. Illovo sugar) to increase their production of ethanol. The public sector would have to play a critical role in distributing land for biofuels feedstock cultivation.

Rural land in the country is usually administered by chiefs and village headmen who have the capacity to determine ownership amongst the rural community (Van-Vlaenderen, 2013). Although some land may appear unused, it usually has some social value for the community whether in the form of communal land for cattle grazing or crop rotation. Therefore it is relatively difficult to estimate how much land might be available for biofuel production. Nevertheless, it remains undeniable that large bodies of land do exist that could be used for biofuels feedstock production within the nation (Hall, 2011).

6.3 Infrastructure & Commodity Prices

The available infrastructure discussed earlier in this paper could be utilised to transport biofuels around Malawi as well as be utilised to import the feedstocks from other countries that may have a surplus in maize production and provide a competitive supply option given logistical dynamics. Like CTL/GTL technologies, the viability of developing a biofuels sector rests heavily on the price of crude oil. At high oil prices these alternative resources become viable and at low prices the development of biofuels is not viable (see Figure 15) (Golinska & Kawa, 2012).

However in order to secure national liquid fuels needs, biofuels could play a significant role in providing an alternative fuel source that consumers could choose from. Brazilian consumers for example have the option of purchasing ethanol gasoline or a combination of the two at the fuel pump. This competition creates a favourable dynamic for the consumer in terms of fuel prices. In order for Malawi to reach a level where this is possible substantial government support would be needed to provide renewable energy companies with a guaranteed price floor of about \$50 if the price of oil drops below \$50/bbl. State support could be in the form of guaranteeing similar policy

measures as those seen in CTL/GTL production: company rebates guaranteed price floors, tax exemptions, et al, together with political support. In addition to this, government would have to put policies in place that promote the importation of fuel flex vehicles that can either run on ethanol, gasoline or a blend of the two (UNDP, 2007).

The Malawian government lacks a single policy document that governs the development of liquid fuels in the region. Therefore there has to be a harmonisation of policy in energy, agriculture and petroleum sectors to guide this process. Figure 17 shows how a biofuel industry could be developed in Malawi. Critical to the development of this is government support in offering import parity pricing for several years amongst other benefits.

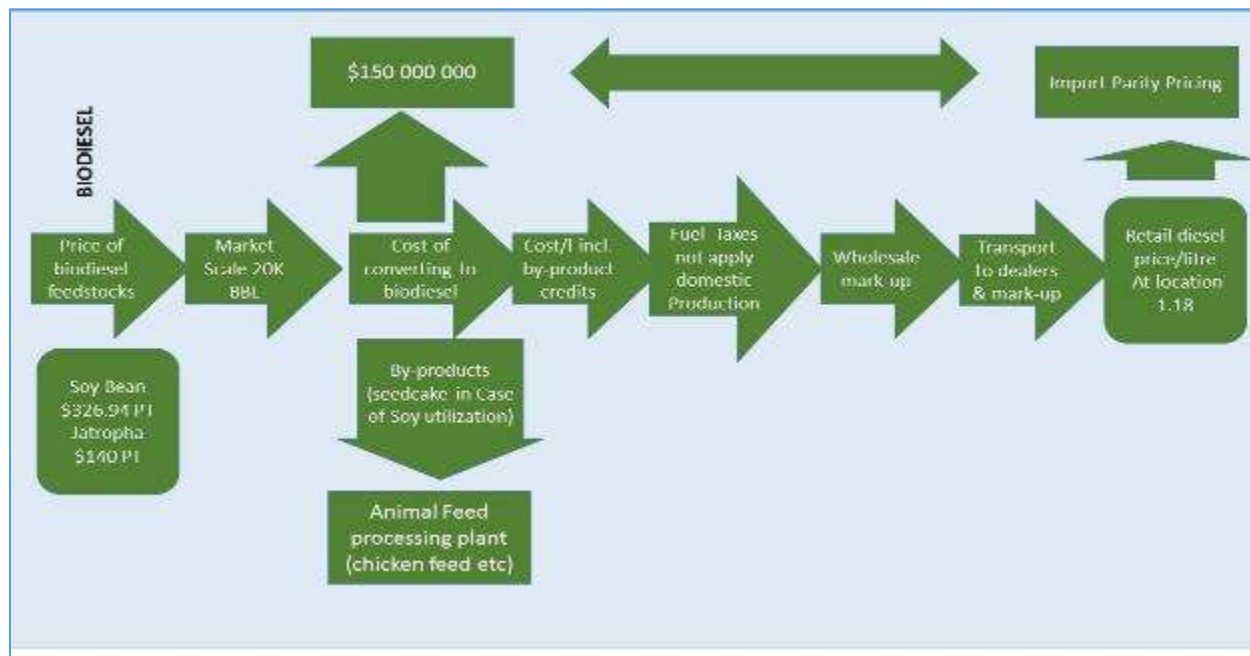


FIGURE 17: FLOW BIOFUEL DEVELOPMENT
MALAWI ENERGY REGULATORY AUTHORITY, 2016

7 Political Economy Analysis PPPs, Foreign Aid, Technology Transfer

7.1 Financing Liquid Fuels projects and issues of Localization

Public and private cooperation is essential for liquid petroleum projects that have been discussed in this paper. Developing nations usually lack the resources on their own to fund projects of this scale. National budgets are limited and reliant on donor nations and

foreign funding (World Bank, 2010). A modular national CTL facility in Malawi would require an investment of 600 million dollars to 1.5 billion dollars. This is a heavy financial investment for Malawi considering that the country's national budget is about 1 billion U.S dollars (Mbwan, 2016).

Private sector finance could be used and funds could be sourced from abroad to build this technology. PPPs as highlighted earlier, must be approached with caution to increase the levels of local content requirements, technology sharing, minimum processing and profit sharing agreements (Amsden, 2007). This is important even more so because of the lack of an indigenous industrial bourgeoisie in the country that could invest in national industrial projects like these on their own. Government support is needed, as indigenous entrepreneurs are constrained to finance and have numerous difficulties in accessing government protection (Rodney, 1973; Fine, 2006).

Significant mining activity in the region has increased the need for infrastructure that is currently inadequate in SADC, to support mining industries. Heavy rail facilities, road networks and ports are limited in the region, therefore private companies are directly investing in the region to provide this infrastructure for example VALE. This private sector investment goes a long way in developing the region. Government intervention is primarily needed in this sector as more often than not aid is tied to conditionality to import capital equipment from the donor nation. This private investment is still a necessary source of investment for developing countries but it has to be met with supporting policies like capital controls to ensure the financial resources are regenerated (Amsden 2008; Chang, 2003).

There is a growing trend of developing countries to own their resources by setting up SOCs to mobilise oil and gas resources in countries as it is feared that private sector participants are likely to exploit oil resources. This usually involves nationalisation of oil resources and there is an underlying distaste for nationalisation policies from donor countries USA, EU for example. Consequently the World Bank discourages the nationalisation of private companies and ties LDCs to bilateral trade and investment agreements to enforce this.

In the 1980's World Bank associates would travel to developing countries offer them loans for infrastructure projects that were too ambitious and consequently LDCs could not pay back (Perkins 2004). Therefore, in order for LDCs to access future loans from the IMF they had to adhere to certain policy conditions. LDCs were promoted to sign bilateral trade agreements with individual western nations that supported the Washington consensus and by LDCs (Perkins, 2004). Lessons from the Washington Consensus have made national governments of sub-Saharan Africa aware of the structures and institutions that have to be in place to get the maximum economic benefit from public private partnerships. The critiques of the theoretical constructs of the policy paradigm of free trade economics have been well documented within heterodox economics and are available to policy makers of sub Saharan African countries that seek them out (Amsden 2007; Chang, 1999; Fine, 2006). Perhaps there is need for a more direct influence and Keynesian stance by RMC governments to develop the liquid fuel industry in SADC. Rodney (1973) puts it perfectly:

“As long as foreigners own land, mines, factories, banks, insurance companies, means of transportation, newspapers, power stations, etc. then for so long will the wealth of Africa flow outwards into the hands of those. In other words, in the absence of direct political control; foreign investment ensures that the natural resources and the labour of Africa produce economic value which is lost to the continent (Rodney, 1973, p. 38).”

7.2 Policies that can assist Malawi to attract investment

It is apparent that private sector investment needs to be matched with considerable public sector support to ensure that the maximum benefit from the project. The Malawian government faces considerable issues and although offtake agreements may contribute to swaying private investment there would be a strong need for the public sector to engage in the process of implementing policies that will increase the viability of a CTL facility. Such policies may include administering the legislative monopoly: petroleum importers limited to sign exclusive off-take agreements with the company for a few years. Government could also get the public utility ESCOM to also engage in secondary off-take agreements to guarantee a secondary revenue stream from a secondary power generation capability that could be incorporated into the facility if

motivated by the industry and significant political support. The same coordination could be applied by the fertilizer importation institutions to motivate the development of a fertilizer complex that would provide a 3rd income stream for the project.

Secondly, if oil prices remain above or equal to the floor price of CTL produced fuels the fuel levy will make conventional fuels less competitive than locally produced fuels. In periods where the oil price falls below the price floor government would have to guarantee that it will intervene and take the necessary policy measures to protect the industry from foreign competition until the industry is at a mature stage. If such a level of dedication is implemented by policy makers, there is potential that Malawi could attract investor appetite to finance and develop CTL technologies.

7.3 Malawian Government Policies on Technical Training and R&D

In order for FDI to be captured to the fullest extent there is need for a strong skills base in the economy. Not all learning can occur within private firms. There is therefore a strong need for Malawi to increase investment in technical skills through the countries technical tertiary institutions. This is a key focus for the country as it forges forward with its implementation of Vision 2020. The aim of the Malawian government is to improve the quality of its human resource. Vision 2020 placed great stock in the improvement and provision of Technical Entrepreneurial Vocational Education and Training (TEVET) (Ministry of Education, 2009). Currently the country is in the process of setting up technical colleges across the country however the programmes in Malawi have been criticised as producing low quality graduates that are not of the quality needed to successfully enter the work force. There is a feeling that government has to do more in managing the tertiary education system particularly in the technology sector. The technical universities are riddled with out dated equipment that cannot develop skilled learners. It is paramount that public funds are devoted to this sector in order to accelerate the reform programs to increase the technical skills in the education sector (Rose, 2010).

A bigger push by government officials would be needed to align the capabilities of the Malawian innovation system to produce graduates with the technical skills that can

engage in R&D. A bigger push is needed in the education sector in order for Malawi to catch up and develop the skills and firm base required to absorb the skills from FDI.

7.4 Environmental Issues

Ghazvinian (2007) in Yates, (2009) sum up environmental concerns perfectly in the description of the experience of the Niger Delta:

“Thousands of miles of pipelines crisscross the mangrove creeks of the delta, broken up by occasional gas flares that send roaring orange flames into the already hot, humid air. Occasionally oil has been spilled into those creeks, and fishing communities disrupted, dislocated or plunged into violent conflict with one another over compensation payments.”

(Ghazvinian (2007) in Yates, (2009)pp.13).

Malawi's agricultural, fishing and tourism sectors are significant to the economy and play a pivotal role in contributing to the economy. Potential drilling oil in the lake poses serious environmental concerns and could be a threat to the livelihood of communities. Therefore there is need for a strong regulatory system to ensure that this is approached with caution. CTL/GTL also have environmental concerns as they produce twice the carbon emissions than that of producing conventional liquid fuels. Consequently to make CTL/GTL projects more viable there is need to utilise recent technologies that produce the least carbon emissions and also to ensure that the location the plant is situated in reservoirs for carbon sequestration.

7.5 Economic Integration

SADC comprises of 15 states and there are political complexities in developing petroleum sectors. Individual nations often do not have the economies of scale or market demand to develop industry, however regionally a case could be built up. Unlike the questionable theory of Say's Law that supply creates its own demand. Individually small economies like Malawi, Zambia, Swaziland, and Lesotho do not have the market scale to develop individual refining capacity on their own, for example. Therefore, there is a strong case for economic integration between nations in SADC that could connect the regions resources (Redvers, 2013). Petrochemical industries that are a result of

refining activities stand to benefit a lot from economic integration as there would be essential economic linkages into other important industries for example agricultural sectors (fertilisers) and manufacturing (polymers and plastics).

Economic integration poses some economic threats to local infant industry as local producers may find it difficult to compete with industry players from neighbouring countries (Redvers, 2013). This may explain Angola's reluctance to fully join the SADC community as competition from member states might wipe out the agricultural infant industry it has as it is a net food importer despite historically being self-sufficient. This would push Angola further into the path of further dependency on oil, an undeniably unfavourable position (Redvers, 2013). Angola is the primary regional producer of oil and is therefore a potential strategic member of SADC. The country's preference for Brazilian and Portuguese food imports goes against its economic integration stance and is detrimental for its status in the community (African Development Bank Group, 2013).

7.6 Resource Curse

Resource curse theorists have highlighted key causes of concern that impact the growth of resource rich economies. Among the main issues are declining terms of trade; the price volatility of commodities in international markets; the tendency for multinational companies to repatriate profits to their home countries and not invest locally; and the effects of Dutch disease.

The terms of trade argument is centred around the idea that developing nations receive too little revenue for their minerals. This is attributable to the economic structures and institutions in the global environment. The economic collapse of international commodity price agreements in the 1980s as well as global crises that have decreased the demand for primary commodities have adversely impacted on the price of commodities and therefore revenues of resource rich producing states (Ross, 1999), affecting the growth rates of the economies. The vulnerability of global commodity prices is also an ailing issue for resource rich countries (Rosser, 2004).

The problem faced by developing countries is that international commodity markets are inherently unstable and therefore sharp price declines in commodity prices can have

massive effects on the revenues of resource reliant countries as these knock on effects could be transferred from the international market to the domestic market. The effect is that foreign exchange reserves are made unreliable, and private sector investment carries high risk (Ross, 1999).

Multinational companies have a tendency to repatriate profits from host nations to home nations rather than investing them locally. This has implications on industries in developing countries as the profits flowing out, if otherwise invested locally into other supporting industries could effectively provide profitable valuable forward and backward linkages into value chains (Ross,1999). (Rosser, 2006) suggests that FDI provides opportunities for well-connected indigenous elites to influence policy via vehicles of their preference. South American elites that controlled natural resources in Latin America had a vested interest in ISI that prevented the development of a robust competitive economy, whereas in east Asia where there was resource poverty such elites did not exist hence the development of a competitive export led growth.

Similar characteristics can be observed in Angola where constitutionally any oil company looking to enter the oil industry has to partner up with Sonangol the Angolan state company whose CEO is the daughter of president Dos Santos. This economic policy can be a beneficial way to govern the resources of the country if the interest of the elite are aligned with the interests of the citizens of the country. However more often than not this is not the case (Osisa, 2004). (Rosser, 2004) argues that an abundance of resources forces countries to integrate into the international capitalist system where the needs of developing countries are subordinated to the needs of the of the developed world therefore causing an imbalance of interests between the interests of multinational companies, political elites and citizens of resource rich nations.

This imbalance of interest between the marriage of government elites and big business versus the interest of the societies they govern arguably influence the development of civil war because of inequalities of wealth and limited political involvement, which in turn fuel divisions in society based on ethnicity religion and other social identifiers. Angola is no stranger to civil war. (Wright &Czulusta, 2004) suggest that countries that are

endowed in diamonds or cocoa are likely to suffer longer periods of civil war. Arguably because rebel groups will fight for territory that has resources that they can use to enrich themselves as well as fund their operations (Wright & Czelusta, 2004). Companies in extractive industries can fund these criminal operations and still reap a normal profit. Naturally there has to be a buyer of the economic resources for the rebel groups to sustain their operations. This is in comparison to companies in a manufacturing economy. Companies in a manufacturing economy would not be able to operate in an unstable environment and would therefore lack the incentive to engage in unscrupulous activities that fuel such activities. Therefore, the enforcement of property is essential and some economic players can reap substantial gains in an unruly environment.

Governments are pivotal to any strategy to reap the rewards from their natural resources. (Di- John, 2004, pp 2) sums it perfectly:

‘In so far as one general conclusion can be drawn from our collection of empirical studies it is that a country's economic performance following a resource boom depends to a considerable extent on the policies followed by its government. Even small economies have considerable influence over their own economic performance.’

It is important for governments to take control of the institutional devices they control and negotiate preferential terms of trade and develop strategies to develop forward and backward linkages into supporting industries.

7.7 Lessons from Kayelekera Uranium Mine

In 2007 the Malawian government signed an agreement to partner up with Paladin Energy. The agreement offered an opportunity for Malawian government to diversify the country's export base. Investment in the infrastructure was carried out and production began. Since then the uranium mining activities have been criticized for several reasons ranging from environmental law abuses to a lack of transparency between the entity and government officials and tax evasion. It has been apparent that the institutional capability of the Malawian government has not been strong enough to regulate the entity (Action-Aid, 2015).

In order to attract the investment, the Malawian government offered substantial tax breaks to Paladin Energy which resulted in the loss of considerable tax revenue. While it is well known that multinational companies often engage in transfer pricing tactics to avoid the full burden of tax payments, little was done by Malawian authorities to mitigate this risk. The lack of regulatory capacity resulted in further tax revenues being lost in the system. Financial losses are not the only issues faced by the limited regulatory capacity (Action-aid, 2015). Environmental abuses have also been reported and have provided negative externalities for surrounding communities.

Public health issues have been observed in the region. Drivers of the trucks that transport the yellow cake have reported experiencing reproduction issues, while local communities have raised concern over pollution of mining waste into the local ecosystem (Personal Communication, 2016).

Following the fall in uranium prices and the nuclear disaster in Japan, events that have led to decreased uranium demand, the mining operations were suspended. Had there been a local beneficiation strategy in place, there could potentially have been a local industry that contributing to domestic demand (Malunga&Phalira, 2014). While the country's economic climate makes the development of such high tier industries challenging, local beneficiation and processing of the uranium could potentially have provided linkages into industries such as power production (Malunga et al, 2014).

The experience from the Kayelekera mine provides some insight into the path the negotiation processes ought to follow. A CTL facility would require strong institutional capacity to regulate environmental abuses and there would need a strong need to enforce local requirements and participation of the local producers. Additionally, government needs to ensure tax regulatory authorities are in place to ensure that companies do not engage in transfer pricing and other strategies that can be used to evade tax. This can only be done with a government to enforce policy and a strong regulatory body to ensure operations of the CTL facility are not producing any negative externalities (Action-Aid, 2014).

8 Policy Recommendations

Governments that wish to diversify their liquid petroleum sectors through CTL/GTL processes, biofuels and the development of infrastructure for intra-regional trade, need to take a more active role. The private sector cannot do for a nation what governments ought to do and the success of any project depends largely on the strength and regulatory capacity of the public sector as well as its ability to coordinate and monitor industry dynamics (Mkandawire, 2010; Chang, 2003).

There is a strong need for economic integration and an investment framework that governs pipeline, road, rail and water transport in order to guarantee that investments in road transport are not favoured over pipeline, rail or water in the region, for political interests. SADC is the organisation that could facilitate this policy cohesion and ensure the transport interconnections. This could be done by the development of a regional pipeline grid that feeds into RMCs.

Laws need to be revisited to increase the viability of such projects. Some level of protectionist policies will need to remain in place until liquid fuel security needs are met. The development of regional pipelines that connect major ports and refineries to landlocked RMCs could address transportation problems of liquid fuels, as currently it is cheaper for Tanzania to source liquid fuels from Gulf/ India via large waterborne tankers than by overland tankers from RSA for example.

Problems within the government itself would have to be addressed. Rent-seeking behaviour would have to be reduced and a character of commitment and dedication would have to be spread across the government organisations. Additionally, government should ensure that government officials are not lobbied by international investors and local entrepreneurs to sign agreements that may not be in the public interest. The presence of unstable governments could deter investors and also have an impact on the development of liquid petroleum projects.

9.0 Conclusions

9.1 Developing Refinery Capacity

Currently Malawi imports its liquid fuels from ex SADC countries at \$53 a barrel. Fuel levies account for approximately 34% of the pump price (Malawi Energy Regulatory Authority, 2016). The wholesale mark-up is unclear and varies from time to time as are transport costs. If a regional pipeline is developed that feeds into Malawi from the main ports or refineries, will have a substantial effect on the current pump price of \$1.18. Therefore in order for Malawi to effectively reduce import prices, the country has to integrate and engage in regional or multi-state projects. Existing pipeline infrastructure connects the port of Beira to Harare.

The Beira Harare pipeline has the capacity to transport 6 million litres of petroleum a day (Nyarota, 2016). There are reports that the Zimbabwean government is looking to increase this capacity to about 16.7 million litres (Nyarota, 2016). The Malawian government could engage Zimbabwean authorities to jointly develop this pipeline and provide it with a link to Mwanza or Zalewa districts in Malawi (distance of approximately 512km). Alternatively if the AZOP pipeline picks up Malawi could develop a link to Zambia but that would be a longer distance (approximately 710 km). Both of the aforementioned pipelines could be linked to the to the Nacala port. A third alternative could be a Mozambique, Malawi, Zambia and Congo pipeline. Figure 18 shows the proposed pipelines routes.

The aforementioned pipeline routes could be viable routes to develop pipeline infrastructure however require further enquiry in terms of scale and market capitalisation. It is important for countries to integrate infrastructural projects regionally because if not delinked infrastructure and unnecessary over capacity could occur (as is currently happening in the EAC where Uganda Kenya Ethiopia and South Sudan are failing to agree on a single pipeline route to benefit all of them).



FIGURE 18: PROPOSED PIPELINE GRID

Source: SADC, (n.d)

Therefore in the interim Malawi would do well to utilise rail and water transport resources that are provided by the central Nacala corridor, southern Sena corridor and the northern Mbeya corridor to transport liquid petroleum.

A regional pipeline grid anchored to the regions petroleum resources would help ease the constraints RMCs currently have. These constraints contribute to the reason this is the reason why the region's refineries import crude from other countries (Gulf) despite being abundant in oil. Angolan oil cannot be transported competitively to the region's refineries therefore when a tanker fills up with Cabinda crude it could go anywhere to the highest bidder, mainly the Peoples Republic of China and the United States of America. Therefore a low cost multi-purpose pipeline grid that connects Angolan crude oil and product to other RMC refineries and storage facilities could be a game changer for SADC.

Pipeline infrastructure is the cheapest mode of transport for liquid fuels and would solve many transport issues. However, it has high scale economies (pipelines need large

volumes to justify high the capex) and would require regional integration as this would have to be a multi-state investment. Therefore SADC RMCs must look at the establishment of a multiple purpose regional pipeline to transport different petroleum products throughout the region at competitive rates. The current pipeline infrastructure is inadequate to serve the region.

Aside from the aforementioned TANZAM pipeline and Harare and Beira pipeline there is further capacity connecting the ports of Richards Bay and Durban to Gauteng. Figure 19 shows the arrangement of the current pipeline grid and the gas link from the Pande-Temane fields to Secunda.



FIGURE 19: SOUTHERN AFRICA PIPELINE GRID (EXCLUDING THE TANZAM PIPELINE)

Source: Countries of the world Pipelines, (n.d)

The development of a regional pipeline grid could provide a basis for the potential development of a refinery in future. The low cost solution a pipeline would provide and regional scale would further increase the viability of such a project. RMCs would have to agree on the tariffs per barrel and coordinate investment accordingly.

9.2 CTL/GTL

CTL/GTL Technologies are uneconomical at low oil prices (roughly 40-50 \$/bbl). Consequently they have to be heavily subsidised during periods of low oil prices, below \$40-\$50/bbl., and may require government offtake agreements. One of the main advantages of CTL technologies is that they produce petrochemicals that can be fed into other industries including fertiliser production. The linkages into other industries provide valuable industrial opportunities for domestic producers if national governments align them in the development of this industry.

The limited size of the Malawian Market make a modular CTL plant more suitable for the country liquid fuel needs. Mott McDonald have been looking at the Liwonde as a prime destination for the development of a CTL refinery. Part of their motivating reasons are the district's rail and water connections that can potentially be used to transport product out of the plant or transport raw materials (coal) to the plant. Therefore if Malawi is to import this technology the country would need to consider a modular facility that can later be upsized to suit growing industry needs. The initial investment cost would be between \$600 000 to \$1.3 billion at phase 1.

The capacity of this plant would be about 3.5k bbl/d of fuel per day which would give an annual equivalent of 200 000 000 litres of petroleum (Mott McDonald in Malawi Ministry of Trade and industry, 2014). Phase 2 would be to develop a fertiliser plant to utilise the bi-products of the plant bringing the total financial investment to about \$1.75 billion. In order to increase viability government would have to guarantee a price floor of about \$65 a barrel on crude oil pricing and award the company import parity pricing models for about 5 to 6 years to allow the company to recoup their investment from liquid petroleum sales (assuming they sell all petroleum products produced)(Mott McDonald in Malawi Ministry of Trade and Industry, 2014).

Regionally a CTL facility could be potentially be developed in Moatize. The Moatize region is an economically viable location for a CTL facility as there are proven coal reserves and there is currently considerable coal mining activity, primarily for coking coal. It is therefore a region for interested stakeholders to consider, as steam coal costs

could be low, as they would be a “discard” from the open-cast coking coal mining (in the overburden). Therefore the plant operators could likely procure the coal for less than \$10 a ton. There would be negligible transport costs as the plant could be located at the mine. This regional plant could also produce the bi-products of refinery processes. A regional coking plant could both satisfy the region’s coke imports and supply the by-product volatiles to a petro-chemicals (F-T) plant as additional feedstock. Therefore, a combination of a coal generation plant and coking plant could also be looked at.

Natural gas resources can also be fed into GTL processes, therefore there is potential for a regional GTL facility in Palma. Like the CTL facility in order for a GTL facility to be viable it has to have significant regional support in terms of RMC offtake agreements not only in the petroleum products produced but also in the bi-products produced. Investment in GTL refinery plants are likely to have more of a significant impact on the Mozambican economy than by developing gas trains for the export of LNG as the export of LNG is more likely to lead to Dutch-disease: skills diversion to the LNG gas industry and limited diversification of the economy. It is therefore important for Mozambican authorities in conjunction with SADC heads of state to develop a common policy framework to govern the development of feedstocks for petroleum products.

9.3 Biofuels

Biofuels are relatively underdeveloped in Malawi. There is a need for the harmonisation of policy in the agricultural, energy and petroleum sectors. This harmonisation of policy and public sector guidance could provide incentives for private sector participants, for example Illovo, to expand their production of biofuels and agricultural output to aid the biofuel (ethanol) industry. This PPP mode of production would be efficient in growing and diversifying the liquid petroleum industry.

An advanced biofuels plant that has the capacity to produce 200 million litres of fuel per annum would cost approximately \$150 million. This would substitute a significant portion of liquid fuels almost half of Malawi’s requirement. Substantial state support in the form of a floor-price would be needed to make this investment viable. Offtake agreements and import parity pricing could provide incentives for the private sector companies like

Illovo to invest in added capacity to produce more cane and ethanol for biofuel feedstocks. A 200 million litre per annum capacity plant would need approximately 4-5 years of import parity pricing support for the investment to be financially viable. Biodiesel production from oil seeds (Table 3) could further provide seed cake that can be fed into animal feed production.

Decentralised modes of biofuel production currently exist within small farming communities in rural Malawi. Farmers utilise small-scale technologies that convert oil seeds and used cooking oil to biodiesel. This mode of production has a low investment value and is currently utilised by individuals and small farming communities. Therefore this production never enters the market (to attract taxes) making it more competitive for farming communities to utilise this form of production to power tractors and other agricultural machinery. The Malawian government has to increase its footprint in this sector and support the development of these technologies through universities and other research institutions as well as offering direct financial support.

Therefore nations that are looking to diversify their liquid fuels industries through CTL/GTL technologies, biofuels and the development of import infrastructures should consider developing a synergy that combines the aforementioned sources. There are environmental advantages that biofuel technologies have over CTL/GTL technologies and that CTL/GTL processes have over liquid fuels imports like the production of petrochemicals that feed into other industries. Therefore a RMCs need to develop energy policies that harmonise all of the aforementioned energy sources. It is important for RMCs to integrate their feedstocks infrastructure so that they can mobilise the resources that are available in the region.

One way to develop regional resources is to review licensing conditions and put in minimum value addition requirements on minerals that foreign MNCs have to adhere to. Some of the areas that could be addressed by this policy are local content requirements, minimum processing of the minerals and competitive prices to downstream beneficiaries, the upgrading of indigenous infrastructure and capital as well as implementing a tax policy that will ensure RMCs get a share of the rents of the growing

mining activity in the region. Control mechanisms need to be in place to ensure that individual RMCs abide by the policy agreements that SADC states collectively agree upon.

Within the right policy environment both, national and regionally, RMCs could effectively implement biofuels, CTL/GTL technologies as well as upgrade and integrate infrastructure. Presently imports are the cheapest option but there is no guarantee that this will be the case in the medium and long term. Therefore RMCs must consider other non-conventional modes that are best suited to the needs of their respective economies with the end goal of supplying the region.

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